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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-076747
(43)Date of publication of application : 15.03.2002

(51)Int.Cl. H01Q 3/26
H04B 7/08
H04B 7/10

(21)Application number : 2000-268608
(22)Date of filing : 05.09.2000

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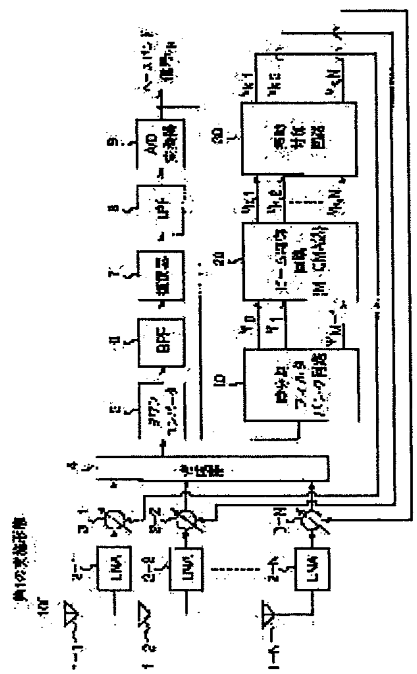
(54) CONTROL DEVICE AND CONTROL METHOD FOR ARRAY ANTENNA

(57)Abstract:
PROBLEM TO BE SOLVED: To enable an accurate beam-null control for the time and the beam forming direction, using a simpler configuration compared with conventional examples.
SOLUTION: By a predetermined phase shift, variable phase shifters 3-1-3-N phase-shift multiple radio signals of N pieces, which are received by an array antenna 100 composed of multiple antenna elements of N pieces, and a summing device 4 puts together and outputs the multiple phase-shifted radio signals of N pieces. A demodulator 7 demodulates radio signals after putting together into baseband signals, and a time division filter bank circuit 10 conducts time division so as to output one sample signal of non-perturbation term and multiple sample signals of perturbation term in series signals as different signals, based on the demodulated baseband signals. A beam control 20 calculates and outputs each phase shift of variable phase shifters 3-1-3-N to conduct adaptive beam control, using a predetermined adaptive beam control method which turns the main beam of the array antenna 100 to a predetermined direction based on the signals after time division processing.



LEGAL STATUS

[Date of request for examination] 20.03.2003

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]	3668419
[Date of registration]	15.04.2005
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（A）　(11)特許出願公開番号
特開2002－76747
（P2002－76747A）
(43)公開日　平成14年３月15日(2002.3.15)

(51)Int.Cl.⁷	識別記号	ＦＩ	テーマコード゛(参考)
Ｈ０１Ｑ　3/26		Ｈ０１Ｑ　3/26	Ｚ　５Ｊ０２１
Ｈ０４Ｂ　7/08		Ｈ０４Ｂ　7/08	Ｄ　５Ｋ０５９
7/10		7/10	Ａ

審査請求　未請求　請求項の数８　ＯＬ　（全 23 頁）

(21)出願番号　特願2000－268608(P2000－268608)

(22)出願日　平成12年９月５日(2000.9.5)

特許法第30条第１項適用申請有り　2000年３月７日　社団法人電子情報通信学会発行の「2000年電子情報通信学会総合大会講演論文集　通信１」に発表

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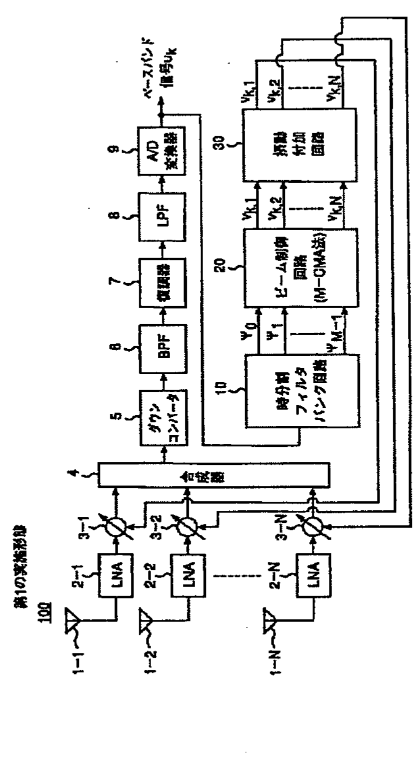
最終頁に続く

(54)【発明の名称】　アレーアンテナの制御装置及び制御方法

(57)【要約】
【課題】　従来例に比較して構成が簡単であって、時間的にかつビーム形成方向として正確にビーム・ヌル制御ができる。
【解決手段】　可変移相器３－１乃至３－Ｎは、複数Ｎ個のアンテナ素子からなるアレーアンテナ１００によって受信された複数Ｎ個の無線信号をそれぞれ所定の移相量だけ移相させ、合成器４は移相された複数Ｎ個の無線信号を合成して出力する。復調器７は合成後の無線信号をベースバンド信号に復調し、時分割フィルタバンク回路１０は復調されたベースバンド信号に基づいて１つの非摂動項のサンプル信号と系列信号内の摂動項の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を行う。ビーム制御回路２０は、時分割処理後の信号に基づいてアレーアンテナ１００の主ビームを所定の方向に向けるような所定の適応ビーム制御法を用いて、可変移相器３－１乃至３－Ｎの各移相量を計算して出力して適応ビーム制御を行う。



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【特許請求の範囲】

【請求項１】　複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号をそれぞれ所定の移相量だけ移相させて出力する複数Ｎ個の移相手段と、
上記各移相手段から出力される複数Ｎ個の無線信号を合成して、合成後の無線信号を出力する合成手段と、
上記合成手段から出力される無線信号をベースバンド信号に復調して出力する復調手段と、
上記復調手段から出力されるベースバンド信号を所定の利得で利得制御して出力する利得制御手段と、
上記利得制御手段から出力されるベースバンド信号と所定値の基準信号との間の誤差信号を発生して出力する減算手段と、
上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記減算手段から出力される誤差信号の電力の傾斜ベクトルを計算し、計算された誤差信号の電力の傾斜ベクトルと上記誤差信号に基づいて当該誤差信号が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための各移相量及び上記利得制御手段の利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力する制御手段とを備えたアレーアンテナの制御装置において、
上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、
上記復調手段と上記利得制御手段との間、又は上記利得制御手段と上記制御手段及び上記減算手段との間に挿入して設けられ、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行する時分割処理手段をさらに備えたことを特徴とするアレーアンテナの制御装置。

【請求項２】　上記利得制御手段は、トランスバーサルフィルタ回路であることを特徴とする請求項１記載のアレーアンテナの制御装置。

【請求項３】　複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号をそれぞれ所定の移相量だけ移相させて出力する複数Ｎ個の移相手段と、
上記各移相手段から出力される複数Ｎ個の無線信号を合成して、合成後の無線信号を出力する合成手段と、
上記合成手段から出力される無線信号をベースバンド信号に復調して出力する復調手段と、
上記復調手段から出力されるベースバンド信号を所定の利得で利得制御して出力する利得制御手段と、
上記利得制御手段から出力されるベースバンド信号の符号を判別して符号判別値を示す符号判別値信号を出力する符号判別手段と、
上記符号判別手段から出力される符号判別値信号と、上

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記利得制御手段から出力されるベースバンド信号との間の誤差信号を発生して出力する減算手段と、
上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記利得制御手段から出力されるベースバンド信号の摂動前後の変化量を計算し、計算された変化量と、上記復調手段から出力されるベースバンド信号と、上記利得制御手段から出力されるベースバンド信号と、上記減算手段から出力される誤差信号とに基づいて、上記誤差信号の自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力する制御手段とを備え、
上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、
上記復調手段と上記利得制御手段との間、又は上記利得制御手段と上記制御手段及び上記減算手段との間に挿入して設けられ、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行する時分割処理手段をさらに備えたことを特徴とするアレーアンテナの制御装置。

【請求項４】　請求項１乃至３のうちの１つに記載のアレーアンテナの制御装置において、
上記復調手段の後段に挿入して設けられ、上記復調手段から出力されるベースバンド信号に対してアナログ・ディジタル変換して、変換後のディジタルのベースバンド信号を出力する変換手段をさらに備えたことを特徴とするアレーアンテナの制御装置。

【請求項５】　複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号を、複数の移相手段を用いて、それぞれ所定の移相量だけ移相させるステップと、
上記移相された複数Ｎ個の無線信号を合成して、合成後の無線信号を出力するステップと、
上記合成後の無線信号をベースバンド信号に復調するステップと、
上記復調されたベースバンド信号を、利得制御手段を用いて所定の利得で利得制御するステップと、
上記利得制御されたベースバンド信号と所定値の基準信号との間の誤差信号を発生するステップと、
上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記誤差信号の電力の傾斜ベクトルを計算し、計算された誤差信号の電力の傾斜ベクトルと上記誤差信号に基づいて当該誤差信号が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための各移相量及び上記利得制御するステップの利得を計算してそれぞれ上記各移相手段及

び上記利得制御手段に出力するステップとを含むアレーアンテナの制御方法において、

上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、

上記復調するステップと上記利得制御するステップとの間、又は上記利得制御するステップと上記計算するステップ及び上記誤差信号を発生するステップとの間で実行され、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行するステップをさらに含むことを特徴とするアレーアンテナの制御方法。

【請求項６】　上記利得制御するステップは、トランスバーサルフィルタ回路を用いて実行されることを特徴とする請求項１記載のアレーアンテナの制御方法。

【請求項７】　複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号を、複数の移相手段を用いてそれぞれ所定の移相量だけ移相させるステップと、

上記移相された複数Ｎ個の無線信号を合成して、合成後の無線信号を出力するステップと、

上記合成後の無線信号をベースバンド信号に復調するステップと、

上記復調されたベースバンド信号を、利得制御手段を用いて所定の利得で利得制御するステップと、

上記利得制御されたベースバンド信号の符号を判別して符号判別値を示す符号判別値信号を出力するステップと、

上記符号判別値信号と、上記利得制御されたベースバンド信号との間の誤差信号を発生するステップと、

上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記利得制御されたベースバンド信号の摂動前後の変化量を計算し、計算された変化量と、上記復調されたベースバンド信号と、上記利得制御されたベースバンド信号と、上記誤差信号とに基づいて、上記誤差信号の自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力するステップとを備え、

上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、

上記復調するステップと上記利得制御するステップとの間、又は上記利得制御するステップと上記計算するステップ及び上記誤差信号を発生するステップとの間で実行され、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行するステップをさらに含むことを特徴とするアレーアンテナの制御方法。

【請求項８】　請求項５乃至７のうちの１つに記載のアレーアンテナの制御方法において、

上記復調するステップの後に実行され、上記復調されたベースバンド信号に対してアナログ・ディジタル変換して、変換後のディジタルのベースバンド信号を出力するステップをさらに含むことを特徴とするアレーアンテナの制御方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、複数のアンテナ素子を備えたアレーアンテナを制御するための制御装置及び制御方法に関する。

【０００２】

【従来の技術】図１０は、従来例のアレーアンテナの制御装置の構成を示すブロック図である。図１０において、複数Ｎ個のアンテナ素子１－１乃至１－Ｎが互いに所定の間隔で１直線上に並置されてなるアレーアンテナ１００によって無線信号が受信され、各アンテナ素子１－１乃至１－Ｎで受信された無線信号はそれぞれ、低雑音増幅器（ＬＮＡ）２－１乃至２－Ｎ、所定の中間周波数の中間周波信号に周波数変換するダウンコンバータ５－１乃至５－Ｎ、中間周波信号をベースバンド信号に復調する復調器７－１乃至７－Ｎ及びアナログ／ディジタル変換を行うＡ／Ｄ変換器９－１乃至９－Ｎを介してビーム制御回路９３及び可変移相器９１－１乃至９１－Ｎに出力される。可変移相器９１－１乃至９１－Ｎはそれぞれ、入力されるベースバンド信号を、ビーム制御回路９３から指示される移相量だけ移相した後、合成器９２に出力する。合成器９２は入力される複数Ｎ個のベースバンド信号を電力合成して、合成後のベースバンド信号をビーム制御回路９３に出力するとともに、外部装置に出力する。

【０００３】ここで、ビーム制御回路９３は、Ａ／Ｄ変換器９－１乃至９－Ｎから入力される各ベースバンド信号と、合成後のベースバンド信号とに基づいて、例えば公知のＬＭＳ（Least Mean Square）法等のＭＭＳＥ（Minimizing Mean Square Error）の基準に基づく手法などの適応ビーム制御アルゴリズムを用いて、合成後のベースバンド信号が最大となりかつアレーアンテナ１００が所定の方向に主ビームを向けるような可変移相器９１－１乃至９１－Ｎの各移相量を計算して各可変移相器９１－１乃至９１－Ｎを制御するために出力する。

【０００４】以上のように構成された、いわゆる適応型アレーアンテナの制御装置は、複数のアンテナ素子１－１乃至１－Ｎ及び無線受信機回路に、デジタル信号処理回路である可変移相器９１－１乃至９１－Ｎ、合成器９２及びビーム制御回路９３を組み合わせることにより、

受信電波環境に適応した指向性パターンを得ることができる高機能なアンテナ制御装置である。図１０の従来例では、ディジタルビーム形成回路（ＤＢＦ）を用いた構成であり、アレーアンテナの主ビームを所望到来波の方向に形成したり、干渉波の方向にヌル点を形成してこれを除去するという機能を有する。

【０００５】しかしながら、アンテナ素子１－１乃至１－Ｎ毎に受信回路（低雑音増幅器２－１乃至２－Ｎ、ダウンコンバータ５－１乃至５－Ｎ、及び復調器７－１乃至７－Ｎ）並びにＡ／Ｄ変換器９－１乃至９－Ｎを用いる必要があるので、ハードウエア規模や消費電力が大きくなるという問題点があった。特に、アンテナ素子の素子数が多い高利得アンテナの場合に特にこの問題は深刻なものとなる。さらに、アンテナ素子毎に受信するので信号レベルが低下した環境下では動作が困難となるという欠点もある。

【０００６】この問題点を解決するために、本発明者らは、例えば、従来技術文献１「田野ほか，“Ｍ－ＣＭＡ（Modified Constant Modulus Algorithm），－マイクロ波信号処理による適応ビーム形成のためのディジタル信号処理アルゴリズム－”，電子情報通信学会研究報告，Ａ・Ｐ９９－６２，ｐｐ．１５－２２，１９９９年」において、このマイクロ波帯でビーム形成を行いディジタル信号処理制御を行うアダプティブアレーに適した適応アルゴリズムとして、Ｍ－ＣＭＡ（ModifiedConstant Modulus Algorithm）が提案されている。このＭ－ＣＭＡ法では、ハードウェア構成の簡易化のため、ビーム形成器を可変移相器と加算器で構成することを前提としている。Ｍ－ＣＭＡ法はＣＭＡ法と同じように振幅偏差の平均自乗誤差の最小化を評価基準とするため、ＣＭＡ法と同様にビームステアリングとヌルステアリングの同時制御が可能である。言うまでもなく、Ｍ－ＣＭＡ法はブラインドアルゴリズムに位置づけられるため、フレーム同期や周波数・位相同期を確立する前にビーム形成可能である。従って、種々の同期確立以前にビーム形成が行われ、ビーム形成器からはＳＩＮＲ（Signal to Interference and NoiseRatio）の高い信号がＩＦ段以降に供給されるため、劣悪なＳＩＮＲ環境下においても種々の同期が容易に確立できるという利点もある。原理的にＭ－ＣＭＡ法は各可変移相器の制御電圧に対する誤差平面における傾斜ベクトルを摂動を用いて推定する。

【０００７】

【発明が解決しようとする課題】しかしながら、Ｍ－ＣＭＡ法では、同じ時刻の受信信号に対して摂動を与えた時のビーム形成器の出力信号（摂動項）と、与えないビーム形成器の出力信号（非摂動項）が更新式において必要になる。これを近似的に求める手段として、高速サンプリングを用いる方法がある。これは摂動をかけると同時に、ビーム形成器の出力信号をシンボルレートに対して高速にサンプリングし、この出力の隣り合った信号を「非摂動項」と「摂動項」として用いるのである。この動作原理には、雑音の影響を無視すれば、高速サンプルされたビーム形成器の出力信号の隣り合った信号の相関は非常に高く、両者の違いは摂動の有り無しの違いだけであることを利用している。ただしこの場合、ビットレートに比較して非常に高速なサンプリングを行えるＡ／Ｄ変換器が必要になること、サンプリングタイミング調整が困難であって、回路構成が複雑になるという問題点があった。

【０００８】本発明の目的は以上の問題点を解決し、従来例に比較して構成が簡単であって、時間的にかつビーム形成方向として正確に主ビームの制御やヌルの制御ができるアレーアンテナの制御装置及び制御方法を提供することにある。

【０００９】

【課題を解決するための手段】本発明に係るアレーアンテナの制御装置は、複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号をそれぞれ所定の移相量だけ移相させて出力する複数Ｎ個の移相手段と、上記各移相手段から出力される複数Ｎ個の無線信号を合成して、合成後の無線信号を出力する合成手段と、上記合成手段から出力される無線信号をベースバンド信号に復調して出力する復調手段と、上記復調手段から出力されるベースバンド信号を所定の利得で利得制御して出力する利得制御手段と、上記利得制御手段から出力されるベースバンド信号と所定値の基準信号との間の誤差信号を発生して出力する減算手段と、上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記減算手段から出力される誤差信号の電力の傾斜ベクトルを計算し、計算された誤差信号の電力の傾斜ベクトルと上記誤差信号に基づいて当該誤差信号が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための各移相量及び上記利得制御手段の利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力する制御手段とを備えたアレーアンテナの制御装置において、上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、上記復調手段と上記利得制御手段との間、又は上記利得制御手段と上記制御手段及び上記減算手段との間に挿入して設けられ、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行する時分割処理手段をさらに備えたことを特徴とする。

【００１０】上記アレーアンテナの制御装置において、上記利得制御手段は、好ましくは、トランスバーサルフィルタ回路であることを特徴とする。

【００１１】また、本発明に係るアレーアンテナの制御

装置は、複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号をそれぞれ所定の移相量だけ移相させて出力する複数Ｎ個の移相手段と、上記各移相手段から出力される複数Ｎ個の無線信号を合成して、合成後の無線信号を出力する合成手段と、上記合成手段から出力される無線信号をベースバンド信号に復調して出力する復調手段と、上記復調手段から出力されるベースバンド信号を所定の利得で利得制御して出力する利得制御手段と、上記利得制御手段から出力されるベースバンド信号の符号を判別して符号判別値を示す符号判別値信号を出力する符号判別手段と、上記符号判別手段から出力される符号判別値信号と、上記利得制御手段から出力されるベースバンド信号との間の誤差信号を発生して出力する減算手段と、上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記利得制御手段から出力されるベースバンド信号の摂動前後の変化量を計算し、計算された変化量と、上記復調手段から出力されるベースバンド信号と、上記利得制御手段から出力されるベースバンド信号と、上記減算手段から出力される誤差信号とに基づいて、上記誤差信号の自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力する制御手段とを備え、上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、上記復調手段と上記利得制御手段との間、又は上記利得制御手段と上記制御手段及び上記減算手段との間に挿入して設けられ、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行する時分割処理手段をさらに備えたことを特徴とする。

【００１２】上記アレーアンテナの制御装置は、好ましくは、上記復調手段の後段に挿入して設けられ、上記復調手段から出力されるベースバンド信号に対してアナログ・ディジタル変換して、変換後のディジタルのベースバンド信号を出力する変換手段をさらに備えたことを特徴とする。

【００１３】さらに、本発明に係るアレーアンテナの制御方法は、複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号を、複数の移相手段を用いて、それぞれ所定の移相量だけ移相させるステップと、上記移相された複数Ｎ個の無線信号を合成して、合成後の無線信号を出力するステップと、上記合成後の無線信号をベースバンド信号に復調するステップと、上記復調されたベースバンド信号を、利得制御手段を用いて所定の利得で利得制御するステップと、上記利得制御されたベースバンド信号と所定値の基準信号との間の誤差信号を発生するステップと、上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記誤差信号の電力の傾斜ベクトルを計算し、計算された誤差信号の電力の傾斜ベクトルと上記誤差信号に基づいて当該誤差信号が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための各移相量及び上記利得制御するステップの利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力するステップとを含むアレーアンテナの制御方法において、上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、上記復調するステップと上記利得制御するステップとの間、又は上記利得制御するステップと上記計算するステップ及び上記誤差信号を発生するステップとの間で実行され、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行するステップをさらに含むことを特徴とする。

【００１４】上記アレーアンテナの制御方法において、上記利得制御するステップは、好ましくは、トランスバーサルフィルタ回路を用いて実行されることを特徴とする。

【００１５】またさらに、本発明に係るアレーアンテナの制御方法は、複数Ｎ個のアンテナ素子が互いに所定の間隔で並置されてなるアレーアンテナの各アンテナ素子で受信された複数Ｎ個の無線信号を、複数の移相手段を用いてそれぞれ所定の移相量だけ移相させるステップと、上記移相された複数Ｎ個の無線信号を合成して、合成後の無線信号を出力するステップと、上記合成後の無線信号をベースバンド信号に復調するステップと、上記復調されたベースバンド信号を、利得制御手段を用いて所定の利得で利得制御するステップと、上記利得制御されたベースバンド信号の符号を判別して符号判別値を示す符号判別値信号を出力するステップと、上記符号判別値信号と、上記利得制御されたベースバンド信号との間の誤差信号を発生するステップと、上記複数の移相手段の各移相量をそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、上記利得制御されたベースバンド信号の摂動前後の変化量を計算し、計算された変化量と、上記復調されたベースバンド信号と、上記利得制御されたベースバンド信号と、上記誤差信号とに基づいて、上記誤差信号の自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得を計算してそれぞれ上記各移相手段及び上記利得制御手段に出力するステップとを備え、上記ベースバンド信号は複数個のサンプル信号を含む系列信号を含み、上記復調するステップと上記利得制御するステップとの間、又は上記利得制御するステップと上記計

算するステップ及び上記誤差信号を発生するステップとの間で実行され、入力されるベースバンド信号に基づいて、摂動されない期間における少なくとも１つのサンプル信号と、摂動された期間における上記系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行するステップをさらに含むことを特徴とする。

【００１６】上記アレーアンテナの制御方法は、好ましくは、上記復調するステップの後に実行され、上記復調されたベースバンド信号に対してアナログ・ディジタル変換して、変換後のディジタルのベースバンド信号を出力するステップをさらに含むことを特徴とする。

【００１７】

【発明の実施の形態】以下、図面を参照して本発明に係る実施形態について説明する。

【００１８】<第１の実施形態>図１は、本発明に係る第１の実施形態であるアレーアンテナの制御装置の構成を示すブロック図であり、図１０と同様のものについては同一の符号を付している。また、図２は、図１の時分割フィルタバンク回路１０とビーム制御回路２０と摂動付加回路３０の詳細な内部構成を示すブロック図である。

【００１９】この第１の実施形態のアレーアンテナの制御装置は、複数Ｎ個のアンテナ素子１－１乃至１－Ｎが互いに所定の間隔で配置されてなるアレーアンテナ１００（例えばリニアアレーであって、２次元形状又は３次元形状で配置されてもよい。）のビームをM－CMA法を用いて制御するためのビーム制御回路２０を備えた適応制御型制御装置において、Ａ／Ｄ変換器９とビーム制御回路３０との間に、入力されるベースバンド信号に基づいて、摂動付加回路３０で摂動されない期間における１つの信号（少なくとも１つの信号でもよい。）と、摂動付加回路３０で摂動された期間におけるトレーニング信号であるM系列信号内の複数のサンプル信号とが異なる出力信号として出力されるように時分割処理を実行する時分割フィルタバンク回路１０を備えたことを特徴としている。すなわち、この実施形態では、M－CMA法を用いたビーム制御における上述の問題を解決する方法としてポリフェーズ表現で構成された時分割フィルタバンク回路１０を利用し、これにより、同時刻における摂動項と非摂動項が厳密な形で得られるため、正確なビーム・ヌル制御を可能にする。ここで、時分割フィルタバンク回路１０内のディジタルフィルタ１３－０乃至１３－（M－１）は、例えば、ディジタル位相変調システムで帯域制限フィルタとして用いられる、ルートロールオフフィルタをポリフェーズ構成したものである。

【００２０】以下、図１に示すアレーアンテナの制御装置の構成について説明する。図１において、複数Ｎ個のアンテナ素子１－１乃至１－Ｎが互いに所定の間隔で配置されてなるアレーアンテナ１００によって無線信号が受信され、各アンテナ素子１－１乃至１－Ｎで受信された無線信号はそれぞれ、低雑音増幅器（ＬＮＡ）２－１乃至２－Ｎを介して可変移相器３－１乃至３－Ｎに入力される。各可変移相器３－１乃至３－Ｎはそれぞれ、入力される無線信号を、摂動付加回路３０から出力される各移相制御電圧$v_{k,i}$（ｉ＝１，２，…，Ｎ）に対応した各移相量だけ移相した後、合成器４に出力する。合成器４は入力されるＮ個の無線信号を電力合成して、合成後の無線信号を、所定の中間周波数の中間周波信号に周波数変換するダウンコンバータ５及び中間周波信号の帯域成分のみを帯域ろ波する帯域通過フィルタ（ＢＰＦ）６を介して復調器７に出力する。復調器７は、入力される無線信号を、送信機側の変調方法（例えば、ＱＰＳＫ、ＰＳＫ、ＦＳＫなど）に対応した復調方法を用いてベースバンド信号に復調して、所望のベースバンド信号のみを取り出す低域通過フィルタ（ＬＰＦ）８を介してＡ／D変換器９に出力する。Ａ／D変換器９は、入力されるアナログのベースバンド信号をディジタルのベースバンド信号にＡ／D変換して、変換後のベースバンド信号信号u_kを外部装置に出力するとともに、時分割フィルタバンク回路１０を介してビーム制御回路２０にに出力する。

【００２１】なお、可変移相器３－１乃至３－Ｎと合成器４とは、例えば公知の大規模ＧａＡｓMMＩＣにてなるマイクロ波シグナルプロセッサによって構成することができる。また、本実施形態においては、ベースバンド信号はトレーニング信号として例えばM系列信号を含み、Ａ／D変換器９のサンプリングレートをｆｓ＝２Mｆｃとする。ここで、Mは１以上の自然数であり、ｆｃはシンボルクロック周波数である。

【００２２】時分割フィルタバンク回路１０は、図２に示すように、互いに縦続に接続されそれぞれ１／（２Mｆｃ）の遅延時間を有する（M－１）個の遅延回路１１－１乃至１１－（M－１）と、それぞれ（M／２）倍のダウンサンプリングレートを有するM個のダウンサンプラ１２－０乃至１２－（M－１）と、それぞれ詳細後述する伝達関数を有し例えばＦＩＲフィルタで構成されるM個のディジタルフィルタ１３－０乃至１３－（M－１）と、それぞれ（１／４）倍のダウンサンプリングレートを有するM個のダウンサンプラ１４－０乃至１４－（M－１）とを備えて構成される。時分割フィルタバンク回路１０において、Ａ／D変換器９からのベースバンド信号u_kは、ダウンサンプラ１２－（M－１）、ディジタルフィルタ１３－（M－１）及びダウンサンプラ１４－（M－１）を介して、時分割処理されたベースバンド信号$\Psi_{k,M-1}$としてビーム制御回路２０に出力されるとともに、互いに縦続接続された（M－１）個の遅延回路１１－（M－１）乃至１１－１を介してダウンサンプラ１２－０に出力される。ここで、遅延回路１１－（M－１）から出力されるベースバンド信号u_kは、ダウン

サンプラ１２－（Ｍ－２）、ディジタルフィルタ１３－（Ｍ－２）及びダウンサンプラ１４－（Ｍ－２）を介して、時分割処理されたベースバンド信号$\Psi_{k,M-2}$としてビーム制御回路２０に出力される。以下、同様にして、遅延回路１１－ｍから出力されるベースバンド信号u_kは、ダウンサンプラ１２－ｍ、ディジタルフィルタ１３－ｍ及びダウンサンプラ１４－ｍを介して、時分割処理されたベースバンド信号$\Psi_{k,m}$としてビーム制御回路２０に出力され、ここで、ｍ＝Ｍ－３，…，０である。

【００２３】図３は、図２の時分割フィルタバンク回路１０の動作例を示すブロック図であり、本実施形態では、一例として、Ｎ＝Ｍ－１の場合を示している。

【００２４】本実施形態では、図３に示すように、１シンボルの時間Ｔを２分割して、時間Ｔ／２において、Ｍ個のサンプル信号（これはM系列信号を対応する。）を含み、Ｍ個のサンプル信号は、摂動付加回路３０で摂動されない期間における１つの非摂動項のサンプル信号（△ｖ＝０）と、摂動付加回路３０で摂動された期間におけるトレーニング信号であるM系列信号内の複数Ｎ（＝Ｍ－１）個の摂動項のサンプル信号（摂動付加電圧△ｖが付加された）とを含む。そして、時分割フィルタバンク回路１０は、Ｍ個のサンプル信号のうち、１つの非摂動項のサンプル信号（△ｖ＝０）と、Ｍ－１個の摂動項のサンプル信号（摂動付加電圧△ｖが付加された）が異なる出力信号として出力されるように時分割処理を実行する。

【００２５】図２において、時分割フィルタバンク回路１０から出力される時分割処理後のベースバンド信号$\Psi_{k,0}$は、ビーム制御部２１に直接に出力されるとともに、ビーム制御部２１により指定される制御利得g_kを有する可変増幅器２２－０を介してビーム制御部２１及び減算器２４に入力される。また、時分割フィルタバンク回路１０から出力される時分割処理後のベースバンド信号$\Psi_{k,m}$は、ビーム制御部２１により指定される制御利得g_kを有する可変増幅器２２－ｍを介してビーム制御部２１に入力され、ここで、ｍ＝１，２，…，Ｍ－１である。ここで、制御利得は正又は負の値をとりうる。一方、基準信号発生器２３は所定の一定値を有する基準信号σを発生して減算器２４に出力する。減算器２４は基準信号σから利得増幅後のベースバンド信号$y_{k,0}$を減算して、その誤差（又は偏差）信号e_kをビーム制御部２１に出力する。ビーム制御部２１は、入力される誤差信号e_kと、それぞれ利得制御されたＭ個のベースバンド信号$y_{k,0}$乃至$y_{k,M-1}$と、利得制御前のベースバンド信号$\Psi_{k,0}$とに基づいて、詳細後述するように、Ｍ－ＣＭＡ法を用いて、摂動付加回路３０のスイッチングコントローラ３２を制御して各可変移相器３－１乃至３－Ｎの各移相制御電圧$v_{k,i}$（ｉ＝１，２，…，Ｎ）を所定のシフト量だけ摂動させ、これにより対応する各移相量を所定の対応シフト量だけ摂動させ、各移相量に対する減算器２２から出力される誤差信号e_kの電力の傾斜ベクトルを計算し、計算された誤差信号e_kの電力の傾斜ベクトルに基づいてＡ／Ｄ変換器９から出力されるベースバンド信号y_kの電力を最大にしかつ、減算器２２から出力される誤差信号e_kに基づいて当該誤差信号e_kが最小となるように、アレーアンテナ１００の主ビームを所定の方向に向けるための各移相量に対応する各移相制御電圧$v_{k,i}$及び可変増幅器２１の増幅度g_kを計算して、計算した各移相制御電圧$v_{k,i}$を摂動付加回路３０を介して各可変移相器３－１乃至３－Ｎに出力するとともに、計算した増幅度g_kを可変増幅器２１に出力する。

【００２６】摂動付加回路３０は、摂動付加電圧△ｖを発生する摂動付加電圧発生器３１と、Ｎ個のスイッチ３４－１乃至３４－Ｎと、Ｎ個の加算器３３－１乃至３３－Ｎとを備えて構成される。ここで、摂動付加電圧発生器３１により発生された摂動付加電圧△ｖはスイッチ３４－１乃至３４－Ｎの各接点ｂに入力され、スイッチ３４－１乃至３４－Ｎの各接点ａはそれぞれ接地されている。これらスイッチ３４－１乃至３４－Ｎの切り換えは、ビーム制御部２１の制御により動作するスイッチコントローラ３２により制御され、ここで、各スイッチ３４－１乃至３４－Ｎは通常接点ａ側に接続されているが、スイッチングコントローラ３２は、例えばトレーニング信号を受信しているときに、図３に示すように、１シンボルの半分の時間Ｔ／２において、M系列信号のＭ＝Ｎ＋１個のサンプル信号のうちの１つの非摂動項のサンプル信号（△ｖ＝０）に続いて、各移相器３－１乃至３－Ｎに対応する複数Ｎ（＝Ｍ－１）個の摂動項のサンプル信号（摂動付加電圧△ｖが付加された）が順次出力されるように、Ｎ個のスイッチ３４－１乃至３４－Ｎのうちの１つのスイッチのみを順次接点ｂ側に切り換えることにより、ビーム制御部２１から出力される移相制御電圧$v_{k,n}$（ｎ＝１，２，…，Ｎ）に対して加算器３３－１乃至３３－Ｎのうちの１つで加算して付加する。摂動付加回路３０から出力される移相制御電圧は移相制御電圧$v_{k,n}$（ｎ＝１，２，…，Ｎ）としてそれぞれ移相器３－１乃至３－Ｎに出力される。

【００２７】なお、トレーニング信号を受信しているときに、摂動付加電圧△ｖを付加するときは、ビーム制御回路２０から出力される移相制御電圧$v_{k,n}$と、摂動付加回路３０から出力される移相制御電圧$v_{k,n}$とは異なるが、説明の便宜上同一の記号を付す。

【００２８】次いで、本実施形態で用いるＭ－ＣＭＡ法の原理と課題について説明する。マイクロ波信号処理によるビーム形成とディジタル信号処理を融合したアダプティブアレーの構成を示す図１では、間隔ｄで空間に配列されたアレーアンテナ１００のアンテナ素子１－１乃至１－Ｎによって受信された受信信号は、ＬＮＡ２－１乃至２－Ｎを介して、ＭＭＩＣ等で構成される可変移相

器３－１乃至３－Ｎによって重み付けされたのち合成器４で加算され、ビーム形成器の出力信号となる。時刻ｋにおいてｉ番目の給電素子で受信された信号を$u_{k,i}$とするとビーム形成器の出力信号s_kは、等価低域モデル（例えば、従来技術文献２「エス．スタインほか，”現代の通信回線理論”，森北出版，１９７０年」参照。）を用いて次式ように表される。

【００２９】

【数１】

$$s_k = s_k(v_{k,1} \quad v_{k,2} \quad \cdots v_{k,1}) = \sum_{i=1}^{N} \exp(-j\theta(v_{k,i}))u_{k,i}$$

【００３０】上記数１において、$v_{k,i}$はｉ番目のアンテナ素子１－ｉに接続された可変移相器３－ｉに印加される制御電圧であり、θ（・）は可変移相器３－ｉの制御電圧に対する移相特性関数であり、Ｎはアンテナ素子の数，ｊは虚数単位を示している。このビーム形成器の出力信号はダウンコンバータ５によりベースバンド帯に変換され、Ａ／Ｄ変換器９によりＡ／Ｄ変換される。ここで、周波数変換された信号s_k’とビーム形成器の出力信号s_kは全く異なったものであるが、周波数変換とフィルタリングが理想的に行われたとすると、両者の違いはｅｘｐ（ｊ２ｐｆｔ）の有無だけである。ただし、ｆは搬送波周波数で、ｉは虚数単位、ｔは時刻を表している。本実施形態では、ビーム形成器の理論上の特性の上界を検証するため、ＲＦ帯の不完全性等は考慮しない。この場合、ｅｘｐ（ｊ２ｐｆｔ）の有無は本質的な問題ではないので、本実施形態では周波数変換された信号s_k’とビーム形成器の出力信号s_kを同一視して説明を行う。

【００３１】Ａ／Ｄ変換された受信信号はベースバンド帯のＡＧＣ増幅器である可変増幅器２２－０乃至２２－（Ｍ－１）により増幅される。増幅後の信号y_kと所望レベルσとの誤差は誤差信号e_kとして次式のように定義される。

【００３２】

【数２】$e_k = \sigma^p - g_k^p | s_k |^p = \sigma^p - | y_k |^p$

ただし、

【数３】$y_k = g_k s_k$

【００３３】ここで、g_kは時刻ｋにおける可変増幅器＊２２－０乃至２２－（Ｍ－１）の利得である。また、上記数２における｜・｜は、複素数の絶対値をとることを意味している。一方、ｐはＭ－ＣＭＡ法における乗数であり、１以上の自然数をとり、本実施形態では例えばｐ＝２である。この、可変増幅器の利得g_kを下記の評価基準によって最適化する。

【００３４】

【数４】$J = E[|e_k|^q] \rightarrow \min$

【００３５】上記数４において、Ｊはコスト関数であり、Ｅ［・］は集合平均を取る関数であり、ｑはｐと共にＭ－ＣＭＡ法の乗数を意味している。従って、数４は、コスト関数Ｊを最小化する評価基準を表している。この解を公知のＳＧＤ（Stochastic Gradient Decent）の原理に基づいて求めると、可変増幅器の利得g_kに関しては以下の式を繰り返すことにより最適値が求められる。

【００３６】

【数５】

$$g_k = g_{k-1} - \mu \frac{\partial J}{\partial g_k} = g_{k-1} + \mu |e_k|^{q-2} e_k |y_k|^{p-1} |s_k|$$

【００３７】上記数５のｍはステップサイズパラメータと呼ばれる係数である。さらに、上記数４の評価基準に基づいて、上記数１のビーム形成器の制御電圧まで最適化を図るなら、ＳＧＤの原理から次式を繰り返すことにより最適値が求まる。

【００３８】

【数６】

$$v_{k,i} = v_{k-1,i} - \mu \frac{\partial J}{\partial v_{k,i}} = v_{k-1,i} + \mu |e_k|^{q-2} e_k |y_k|^{p-1} \Delta_i |y_k|$$

【００３９】ここで、Δ_i｜・｜はｉ番目のアンテナ素子１－ｉに接続された可変移相器３－ｉの制御電圧に対する微係数を表しており、以下のように近似的に求める。

【００４０】

【数７】

$$\Delta_i |y_k| = g_k \Delta_i |s_k(v_{k,1} \quad v_{k,2} \quad \cdots \quad v_{k,N})| = g_k\{|s_k(v_{k,1} \quad \cdots \quad v_{k,i}+\Delta v \quad \cdots \quad v_{k,1})| - |s_k(v_{k,1} \quad \cdots \quad v_{k,j} \quad \cdots \quad v_{k,1})|\}$$

【００４１】上記数６を用いることにより、可変増幅器の利得g_kだけでなく、通常のＣＭＡ法と同様に数２で定義された振幅偏差までも抑圧することができる。ただし、上記数６及び数７から制御電圧の最適値を求めるに

は同時刻の「摂動項」と「非摂動項」が必要になる。これは、摂動をかけると同時に、シンボルレートに比較して高速にＡ／Ｄ変換し、隣あった信号を利用することで解決できる。すなわち、隣り合った信号は信号相関が高いため、ほとんど同一と見なせ、かつその片方が摂動を受けているため上記の要求条件を満足できる。しかしながら、精度を上げるには、かなり高速でサンプルする必要があり、今後ビットレートが高速化することを考慮するとハードウェアの実現が困難となる。そこで、本実施形態では、このサンプリングレートを低減でき、高精度な「非摂動項」、「摂動項」を得るために時分割フィルタバンク回路１０を利用しており、次いで、これについて詳述する。

【００４２】上記数１で示されたビーム形成器の出力信号はダウンコンバータ５によって周波数変換され、Ａ／Ｄ変換器９によってディジタル信号に変換されるが、その時のサンプリングレートを情報レートのM倍で行い、ディジタルフィルタで不要信号の除去を行い、デシメーションを行うことで復調信号を得るシステムを利用する。このディジタルフィルタをＦＩＲ（Finite Impulse Response）フィルタで構成する場合、一般にその伝達関数Ｔ（$z^{-1/M}$）は以下のようにポリフェーズ表現することができる。

【００４３】

【数８】

$$\begin{aligned}
&T(z^{-1/M})\\
&=\sum_{i=-ML}^{ML-1} h_{i/M} z^{-i/M}\\
&=\sum_{i_2=0}^{M-1}\sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} z^{-i_1-i_2/M}\\
&=\sum_{i_2=0}^{M-1} z^{-i_2/M}\sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} z^{-i_1}\\
&=\sum_{i_2=0}^{M-1} T_{i_2}(z^{-1})
\end{aligned}$$

＊【００４４】ただし、T_l（z^{-1}），ｌ＝０，…，Ｍ－１は各ポリフェーズフィルタを構成するフィルタバンクであり、次式のように定義される。

【００４５】

【数９】

$$T_l(z^{-1})=z^{-l/M}\sum_{i=-L}^{L-1} h_{i+l/M} z^{-i}$$

【００４６】各フィルタの入力信号は、バンク内の各フィルタの動作速度がナイキストレート以上であれば、サンプリングレートに関わらず一定のスペクトラム情報を保持している。このとき、雑音がなければすべてのフィルタバンクからは、同一の信号が出力される。ただし、以下の条件を満足させる必要がある。

【００４７】

【数１０】

T_l（z^{-1}）＝T_m（z^{-1}）；ｌ，ｍ＝０，…，Ｍ－１

【００４８】ここで、当該フィルタバンクにより同一の信号が得られることを示す。入力信号を$u_{k-(i+l/M)}$とすると、上記数１０で定義されたポリフェーズフィルタの出力信号は次式のように表される。

【００４９】

【数１１】

$$\psi_{k,l}=\sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)}$$

【００５０】この信号をＤＦＴ（Digital Furrier Transform）すると次式のように表される。

【００５１】

【数１２】

＊

$$\begin{aligned}
&F(\psi_{k,l})\\
&=\sum_{i=0}^{N-1}\sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)} \exp(-j2\pi\frac{kn}{N})\\
&=\sum_{i=-L}^{L-1} h_{i+l/M} \exp(-j2\pi\frac{(i+l/M)n}{N})\sum_{k=0}^{N-1} u_{k-(i+l/M)} \exp(-j2\pi\frac{(k-(i+l/M))n}{N})\\
&=F(h_i)F(u_k)
\end{aligned}$$

【００５２】ただし、Ｆ（・）は・のＤＦＴ後の信号を表している。すなわち、全てのポリフェーズフィルタからは同一の周波数スペクトラムを持つ信号が得られる。従って、この出力をＩＤＦＴ（Inverse DFT）すれば疑いもなく同一の時系列が得られる。

【００５３】次いで、ポリフェーズ表現のフィルタバンクの伝達関数を行列表現するため、次式で定義する遅延行列Ｆ（ｌ）を導入する。

【００５４】

【数１３】Φ（ｌ）≡ｄｉａｇ［z^{-1}　$z^{-1-1/M}$　…

$z^{-1-(M-1)/M}]$

$l=-L, \cdots, L-1$

【００５５】ここで、≡は「定義する」ことを意味し、ｄｉａｇ（・）は括弧内ベクトルを対角要素とする対角行列を意味している。この遅延行列を用いることで、フィルタバンクの伝達関数は次式のようにベクトル表現できる。

【００５６】

【数１４】

$$\Phi \equiv [T_0(z) \quad T_1(z) \quad \cdots \quad T_{M-1}(z)]^T = [\Phi(-L) \quad \Phi(-L+1) \quad \cdots \quad \Phi(L-1)]\,H$$

【００５７】ただし、$H=[h_{-L}, h_{-L+1/M}, \cdots, h_{L+(M-1)/M}]^T$ はポリフェーズ化される前のフィルタのインパルス応答を表している。一方、数１で表されるビーム形成器において、１番目のアンテナ素子１－１から順次摂動をかけていく場合、その出力信号は以下のように数式表現できる。

【００５８】

【数１５】

$$\begin{aligned} S_k &= diag[s_k \quad s_{k+1/M} \quad \cdots \quad s_{k+(M-1)/M}]^T \\ &= [W_{k,1} \quad W_{k,2} \quad \cdots \quad W_{k,N}]\begin{bmatrix} U_{k,1} \\ U_{k,2} \\ \vdots \\ U_{k,N} \end{bmatrix} \end{aligned}$$

＊【００５９】上記数１５における$U_{k,i}$と$W_{k,i}$はそれぞれｉ番目のアンテナ素子１－ｉの出力信号と、その出力信号に対する重み係数行列であり、次式のように表される。

【００６０】

【数１６】$W_{k,i}=diag[\exp(-j\theta(v_{k,i})) \quad \exp(-j\theta(v_{k+1/M,i})) \cdots \quad \exp(-j\theta(v_{k+(M-1)/M,i}))]$

【数１７】$U_{k,i}=diag[u_{k,i} \quad u_{k-1/M,i} \quad \cdots \quad u_{k-(M-1)/M,i}]$

【００６１】このビーム形成器の出力信号を上記数１４で表されたポリフェーズフィルタバンクである時分割フィルタバンク回路１０に入力すると、可変増幅器２２－０乃至２２－（Ｍ－１）への入力信号が得られる。すなわち上記数１４に出力信号を入力して逆ｚ変換すると、その出力信号ベクトルΨ_kは上記数１５で定義された行列を用いて次式のように表される。

【００６２】

【数１８】

＊

$$\Psi_k = \begin{bmatrix} W_{k,1} \\ W_{k,2} \\ \vdots \\ W_{k,N} \end{bmatrix}^T \begin{bmatrix} U_{k+L,1} & U_{k+L-1,1} & \cdots & U_{k-(L-1),1} \\ U_{k+L,2} & U_{k+L-1,2} & \cdots & U_{k-(L-1),2} \\ \vdots & \vdots & \ddots & \vdots \\ U_{k+L,N} & U_{k+L-1,N} & \cdots & U_{k-(L-1),N} \end{bmatrix} H$$

【００６３】ここで、ベクトル$\Theta_{k,i}$を

【数１９】$\Theta_{k,i} \equiv [U_{k+L,i}, \cdots, U_{k-(L-1),i}]\,H$

と導入する。ここで、雑音の影響がなく、上記数１０の条件が満足されていれば、上述のようにベクトル$\Theta_{k,i}$の要素は全て同一となる（数１１及び数１２を用いて上述した通りである。）そこで、その値を$\theta_{k,i}$とおくと、ベクトルＰ＝［１，…，１］を用いて、ベクトル$\Theta_{k,i}$は

【数２０】$\Theta_{k,i} \equiv \theta_{k,i} P$

と表される。すると上記数１８も次式のように書き換えられる。

【００６４】

【数２１】

$$\begin{aligned} \Psi_k &= \sum_{i=1}^{N} \theta_{k,j} W_{k,j} P = [\cdots \quad \psi_{k,l} \quad \cdots] \\ &= [\cdots \quad \sum_{i=1}^{N} \theta_{k,j} \exp(-j\theta(v_{k+l/M,i})) \quad \cdots]^T \\ l &= 0, \cdots M-1 \end{aligned}$$

【００６５】上記数２１は各アンテナ素子１－１乃至１－Ｎからの信号を一旦、ベースバンド帯に変換し、伝達関数Ｔ（ｚ）のディジタルフィルタを通過した後に、重み係数

【数２２】$W_k^T=[\exp(-j2\theta(v_{k,i})), \cdots, \exp(-j2\theta(v_{k+1/M,i})), \cdots]$

で重み付けしたものと等価な信号が、ポリフェーズフィルタバンクである時分割フィルタバンク回路１０の１／

M番目のフィルタから出力されることを意味している。そこで、重み係数$W_{k,i}$を次式のように動作させる。ただし、M≧N＋１とする（図１乃至図３の実施形態では、M＝N＋１としている。）。

【００６６】

【数２３】$v_{k+1/M,i}=v_{k,i}$；$i\neq 1$のとき

$v_{k+1/M,i}=v_{k,i}+\Delta v$；$i\neq 1$のとき

ここで、$i=1,\cdots,N$, 及び$l=0,\cdots,M-1$である。

【００６７】すなわち、M個の連続した入力信号系列において、最初のサンプル信号には全く摂動を与えず、その次のサンプルから各素子に接続された可変移相器３－１乃至３－Nの制御電圧に摂動を順次かけていく。具体的には、１番目のサンプル信号では、１番目の可変移相器３－１の制御電圧にだけ摂動を与える。これにより、ポリフェーズフィルタバンクである時分割フィルタバンク回路１０の０番目のフィルタ（図２の時分割フィルタバンク回路１０では、ディジタルフィルタ１３－０及びダウンサンプラ１４－０）からは非摂動項の信号$\Psi_{k,0}$が出力され、１番目のフィルタ（図２の時分割フィルタバンク回路１０では、ディジタルフィルタ１３－１及びダウンサンプラ１４－１）からは１番目のアンテナ素子１－１に対する摂動項の信号$\Psi_{k,1}$が出力される。従って、ポリフェーズフィルタを応用することで、上述した問題が解決できることがわかる。すなわち、ポリフェーズフィルタを応用したM－CMA法のアダプティブアレーは以下の逐次的な係数更新式に基づき最適係数を求めることができる。

【００６８】

【数２４】$y_{k,i}=g_k\Psi_{k,i}$

ここで、$i=0,1,\cdots,M-1$

【数２５】$e_k=\sigma^p-|y_{k,0}|^p$

【数２６】$v_{k,i}=v_{k-1,i}+\mu|e_k|^{q-2}e_k|y_{k,0}|^{p-1}(|y_{k,i}|-|y_{k,0}|)$

ここで、$i=0,\cdots,M-1$

【数２７】

$g_{k-1}=g_{k-1}+\mu|e_k|^{q-2}e_k|y_{k,0}|^{p-1}|\Psi_{k,0}|$

【００６９】一般に、ポリフェーズフィルタとしてはアンチエリアジングフィルタが適用されるが、通信システムではA／D変換器９の前にアナログ低域通過フィルタが備えられているため、アンチエリアジングフィルタは不要である。そこで、本実施形態では、例えば、位相変調システムでしばしば利用されるナイキストフィルタ系における、受信機のルートロールオフフィルタをポリフェーズ化することにより時分割フィルタバンク回路１０を構成する。

【００７０】図１において、A／D変換器９によるA／D変換前にエリアジングフィルタである低域通過フィルタ８を経た後にポリフェーズフィルタである時分割フィルタバンク回路１０に入力される。図２の時分割フィルタバンク回路１０であるポリフェーズフィルタバンク内の各ルートロールオフフィルタであるディジタルフィルタ１３－０乃至１３－（M－１）は、信号にエリアジング歪みを与えないようにナイキストレートの２倍以上で動作させる必要がある。従って、ルートロールオフトフィルタをM－フェーズ化する場合には、A／D変換器９はナイキストレートの２M倍以上でサンプルする必要がある（本実施形態では、サンプリングレートを上述のように、f＝２Mfcとしている。）。そして、縦続接続された遅延回路１１－１乃至１１－（M－１）により時分割した後、M／２倍のダウンサンプラ１２－０乃至１２－（M－１）でM／２倍にデシメーションし、ディジタルフィルタ１３－０乃至１３－（M－１）を経た後、４倍のダウンサンプラ１４－０乃至１４－（M－１）で４倍にデシメーションすることにより、時分割処理された並列でM個のサンプル信号からなるM系列の復調信号を得る。なお、ダウンサンプラ１２－０乃至１２－（M－１）の倍数と、ダウンサンプラ１４－０乃至１４－（M－１）の倍数は、好ましくは、それらの積が２Mとなるように選択される。

【００７１】時分割フィルタバンク回路１０の動作例を示す図３では、１シンボル内を２（N＋１）倍、すなわちアンテナの素子数N＋１の２倍でオーバサンプルし、N＋１個のフィルタバンクに分配する。各フィルタバンクはシンボルレートの２倍で演算を行う。一方、同期して１／２シンボル内で順次、各アンテナ素子１－１乃至１－Nに接続された可変移相器３－１乃至３－Nに対して摂動を与える。ただし、必ず１／２シンボル毎に摂動をリセットし、すなわち、非摂動項の信号を発生させる。なお、図３では１シンボル内で全ての摂動を行ったが、１シンボルの信号を受信する毎に１つのアンテナ素子の可変移相器への摂動を与え、これを１素子ずつ行いことで演算速度を低減させることも可能である。この場合、N個のシンボル信号を受信して初めて、全素子の摂動を終了する。ただし、摂動を与えない期間を１／２シンボルに挿入する必要があることを考慮すると、サンプリングレートはシンボルレートの４倍まで低減できる。

【００７２】以上説明したように、本実施形態によれば、ポリフェーズフィルタバンクである時分割フィルタバンク回路１０を用いることにより、処理すべき信号のレートを低下させかつ各アンテナ素子に対応する複数の摂動項の信号を正確に取り出すことができる。従って、ビットレートに比較して非常に高速なサンプリングを行えるA／D変換器を必要とせず、低速となるのでサンプリングのタイミング調整も容易となる。それ故、回路構成が簡単であって、時間的正確にかつ、ビーム形成方向として正確に主ビームの制御やヌルの制御ができる。

【００７３】<第１の変形例>図４は、第１の実施形態の変形例である、本発明に係る第１の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１

０とビーム制御回路２０ａの構成を示すブロック図であり、図１及び図２と同一のものは同一の符号を付している。

【００７４】第１の実施形態においては、Ｍ個の可変増幅器２２−０乃至２２−（Ｍ−１）を時分割フィルタバンク回路１０とビーム制御部２１との間に備えていたが、これに代えて、ビーム制御部２１で指定される制御利得g_kを有する１個の可変増幅器２２をＡ／Ｄ変換器９と、時分割フィルタバンク回路１０との間に挿入したことを特徴としている。ここで、ビーム制御部２１は、Ｍ−ＣＭＡ法によるビーム制御処理において、利得制御前のベースバンド信号$y_{k,0}$（図２のベースバンド信号$\Psi_{k,0}$）を必要とするが、これは、図４の時分割フィルタバンク回路１０から出力されるベースバンド信号$\Psi_{k,0}$を制御利得g_kで除算することにより計算することができる。また、これにとって代わって、図４において１点鎖線で示すように、Ａ／Ｄ変換器９からのベースバンド信号u_kから利得制御前のベースバンド信号$y_{k,0}$（図２のベースバンド信号$\Psi_{k,0}$）を時分割分離して取り出してもよい。

【００７５】以上のように構成された第１の変形例によれば、第１の実施形態における作用効果に加えて、可変増幅器２２の個数を大幅に減少させることができ、これにより、回路構成をより簡単にできるという特有の効果を有する。

【００７６】＜第２の実施形態＞図５は、本発明に係る第２の実施形態であるアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｔの構成を示すブロック図であり、図５のＴＲＦ回路６１−１乃至６１−（Ｍ−１）（以下、総称して、符号６１を付す。）の詳細な内部構成を示すブロック図であり、図１乃至図４及び図１０と同一のものについては同一の符号を付している。この第２の実施形態のアレーアンテナの制御装置は、第１の実施形態に係る図１及び図２のビーム制御回路２０に代えて、ＴＤＬ（Tapped Delay Line;タップ付き遅延線）回路７０を有するトランスバーサルフィルタ回路（以下、ＴＲＦ回路という。）６１を備えるとともに、詳細後述する時空間信号処理Ｍ−ＣＭＡ法を用いて適応型のビーム制御を行うビーム制御部２１ｔを備えるビーム制御回路２１ｔを備えたことを特徴としている。その他の構成は第１の実施形態と同様であり、ここで詳細説明を省略する。

【００７７】図５において、Ａ／Ｄ変換器９から時分割フィルタバンク回路１０を介して出力されるベースバンド信号$\Psi_{k,m}$（ｍ＝０，１，２，…，Ｍ−１）は、ビーム制御部２１ｔ及びＴＲＦ回路６１内の可変増幅器７２−０に入力されるとともに、複数（Ｌ−１）個の遅延回路７１−１乃至７１−（Ｌ−１）が縦続接続されてなるＴＤＬ回路７０の第１段の遅延回路７１−１に入力される。上記ベースバンド信号$\Psi_{k,m}$は可変増幅器７２−０を介して加算器７３に出力されるとともに、複数（Ｌ−１）段の遅延回路７１−１乃至７１−（Ｌ−１）及び可変増幅器７２−（Ｌ−１）を介してビーム制御部２１ｔ及び加算器７３に出力される。ＴＤＬ回路７０において、各遅延回路７１−１乃至７１−（Ｌ−１）はそれぞれ入力される信号を所定の遅延時間τだけ遅延して出力する。ここで、遅延時間τは、好ましくは１シンボル時間の１／２に設定されるが、例えば１シンボル時間、もしくはそれ以下に設定されてもよい。

【００７８】遅延回路７１−１から出力される、ベースバンド信号$\Psi_{k,m}=bp_k$の遅延信号bp_{k-1}はビーム制御部２１ｔに出力されるとともに、可変増幅器７２−１を介して加算器７３に出力される。また、遅延回路７１−２から出力されるベースバンド信号bp_kの遅延信号bp_{k-2}はビーム制御部２１ｔに出力されるとともに、可変増幅器７２−２を介して加算器７３に出力される。さらに、遅延回路７１−３から出力されるベースバンド信号bp_kの遅延信号bp_{k-3}はビーム制御部２１ｔに出力されるとともに、可変増幅器７２−３を介して加算器７３に出力される。さらに同様にして、遅延回路７１−（Ｌ−２）から出力されるベースバンド信号bp_kの遅延信号bp_{k-L}はビーム制御部２１ｔに出力されるとともに、可変増幅器７２−（Ｌ−２）を介して加算器７３に出力される。ここで、可変増幅器（又は利得制御器）７２−０乃至７２−（Ｌ−１）はそれぞれ、ビーム制御部２１ｔにより設定される増幅度w_0乃至w_{L-1}で入力される信号を増幅（又は利得制御）して出力し、ここで、増幅度（又は利得）は正又負の値をとる。そして、加算器７３は入力されるベースバンド信号bp_k及びその複数（Ｌ−１）個の遅延信号bp_{k-1}乃至bp_{k-L+1}を加算して加算結果の信号を出力信号$y_{k,m}$（ｍ＝０，１，２，…，Ｍ−１）としてビーム制御部２１ｔに出力する。なお、出力信号$y_{k,0}$は、減算器２４にも出力される。このように構成することにより、ＴＤＬ回路７０と、可変増幅器７２−０乃至７２−（Ｌ−１）と、加算器７３とを備えたＴＲＦ回路６１を構成する。すなわち、第２の実施形態では、第１の実施形態における各可変増幅器２２−０乃至２２−（Ｍ−１）を図６のＴＲＦ回路６１で構成している。

【００７９】一方、基準信号発生器２３は所定の一定値を有する基準信号σを発生して減算器２４に出力する。減算器２４は基準信号σから出力信号$y_{k,0}$を減算して、その誤差（又は偏差）信号e_kをビーム制御部２１ｔに出力する。ビーム制御部２１ｔは、入力される誤差信号e_kと、ベースバンド信号bk_kと、その遅延信号bk_{k-1}乃至y_{k-L+1}と、ＴＲＦ回路６１−０乃至６１−（Ｍ−１）の通過後のベースバンド信号$y_{k,m}$（ｍ＝０，１，２，…，Ｍ−１）とに基づいて、時空間信号処理Ｍ−ＣＭＡ法を用いて、各可変移相器３−１乃至３−Ｎの各移相制御電圧$v_{k,i}$（ｉ＝１，２，…，Ｎ）を摂

動付加回路３０を制御することにより所定のシフト量だけ摂動させ、これにより対応する各移相量を所定の対応シフト量だけ摂動させ、各移相量に対する減算器２４から出力される誤差信号e_kの電力の傾斜ベクトルを計算し、計算された誤差信号e_kの電力の傾斜ベクトルに基づいて、減算器２４から出力される誤差信号e_kに基づいて当該誤差信号e_kが最小となるように、アレーアンテナ１００の主ビームを所定の方向に向けるための各移相量に対応する各移相制御電圧$v_{k,i}$及び各可変増幅器７２－０乃至７２－（Ｌ－１）の増幅度w_0乃至w_{L-1}を計算してそれぞれ各可変移相器３－１乃至３－Ｎ及び各可変増幅器７２－０乃至７２－（Ｌ－１）に出力して設定する。

【００８０】以上のように構成された第２の実施形態に係るアレーアンテナの制御装置においては、ビーム制御回路２０ｔは、誤差信号e_kが最小となるように、アレーアンテナ１００の主ビームを希望波方向に向けかつ、干渉波方向にヌルを向けるように、適確に適応ビーム制御することができる。また、マルチパス伝送路において生じる希望波の遅延波をＴＲＦ回路６１を用いて取り込んで同相合成することができ、希望波における信号対雑音電力比（Ｓ／Ｎ）を改善することができる。また、第＊２の実施形態では、低雑音増幅器２－１乃至２－Ｎ及び可変移相器３－１乃至３－Ｎは、アンテナ素子１－１乃至１－Ｎの素子数Ｎに対応したＮ個を必要とするが、合成器４以降の回路では、各回路構成要素は１つのみで済む。従って、図１０に示す従来例に比較して、従来例に比較してハードウエア構成が簡単であって、回路構成要素の数が少ないので消費電力が少ない。

【００８１】次いで、第２の実施形態で用いる適応ビーム処理について以下に説明する。第２の実施形態に係るアダプティブアレーアンテナの構成において、ベースバンド信号$y_k = y_k(v_{k,1}, \cdots, v_{k,N})$は公知の等価低域モデルを用いて上記の数１のように表わすことができる。このベースバンド信号y_kは、ＴＤＬ回路７０を有するＴＲＦ回路６１に入力される。ＴＲＦ回路６１では、ＴＤＬ回路７０の各タップから出力される信号はそれぞれ、可変増幅器７２－０乃至７２－（Ｌ－１）によりタップ係数である増幅度$w_k(i)$で重み付けされた後、加算器７３で加算されて、以下に示す出力信号$y_{k,m}$（$=z_k$とおく。）を出力する。

【００８２】

【数２８】

$$z_k(v_{k,1},\dots v_{k,N}) = \sum_{i=0}^{L-1} w_k^*(i)\ bp_{k-i}(v_{k,1},\cdots,\ v_{k,N})$$

【００８３】ここで、ビームとヌルのブラインド制御を行うため、公知のＣＭＡ法と同様に、ＴＲＦ回路６１の出力信号z_kの振幅偏差の最小化を図る。すなわち、出力信号$y_{k,0} = z_k$と基準信号σとの誤差を次式のように定義すると、

【数２９】$e_k = \sigma^p - |z_k(v_{k,1}, \cdots, v_{k,N})|^p$

以下の式を満足することが必要条件となる。ただし、σは基準信号のレベルであり、所望の振幅レベルを示している。

【００８４】

【数３０】

$$E\left[\frac{\partial e^q}{\partial v_{k,i}}\right] = 0 \qquad (i=1,\cdots,\ N)$$

【数３１】

$$E\left[\frac{\partial e^q}{\partial v_{k,i}^*}\right] = 0 \qquad (i=0,\cdots,\ L-1)$$

※【００８５】ここで、ｐとｑはＣＭＡ法の推定の次元を示すもので、実際は、ｐ＝ｑ＝２のときがＣＭＡ法と呼ばれ、それ以外はゴダードのアルゴリズムと呼ばれる。数３０の偏微分は、上記数１と数２８によりＣＭＡ法では求めることができない。そこで、本実施形態においては、第１の実施形態に係るＭ－ＣＭＡと同様に、可変移相器３－１乃至３－Ｎの制御電圧$v_{k,1}, \cdots, v_{k,N}$を摂動させて、これにより各移相量を摂動させて求める。また、上記数３１は通常のＣＭＡ法と同様に求めることができる。ここで、出力信号z_kを$z_k = z_k(v_k(1), \cdots, v_k(N))$として、係数更新処理を以下のように行う。

【００８６】上記数２９を誤差関数とし、上記数３０及び数３１を満足する解を探すアルゴリズムは、公知の最急降下法の原理を適用すれば、次式のように表わすことができる。

【００８７】

※ 【数３２】

$$v_k = v_{k-1} - \mu\frac{\partial e_k^q}{\partial v_{k,i}} \fallingdotseq v_{k-1} + \mu\ e_k^{q-1} |z_k|^{p-2} \frac{\partial |z_k|}{\partial v_{k,i}}$$

【数３３】

$$w_k = w_{k-1} - \mu\frac{\partial e_k^q}{\partial w_k(i)} = w_{k-1} + \mu\ e_k^{q-1} |z_k|^{p-2} \frac{\partial |z_k|}{\partial w_k^*(i)}$$

【００８８】上記数３２と数３３はそれぞれ、上記数３０及び数３１を満足するさせるためのアルゴリズムの式である。上記数３２における偏微分項は、上記数２６の偏微分の近似式を用いて得ることができる。一方、上記数３１における偏微分項は、上記数２８の両辺を偏微分することによって直接的に求めることができる。従って、上記数３２及び数３３は次式となり、次式の係数更新式を用いて収束処理を実行する。

【００８９】

【数３４】$v_{k,i} = v_{k-1,i} + \mu_v e_k^{q-1} |z_k|^{p-2} \Delta_i |z_k|$, $(i=1, \cdots N)$

【数３５】$w_k(i) = w_{k-1}(i) + \mu_w e_k^{q-1} |z_k|^{p-2} z_k^* y_k$, $(i=0, \cdots L-1)$

【００９０】ただし、

【数３６】
$$\Delta_i |z_k| = \Delta_i |z_k(v_{k,1}, \cdots, v_{k,i}, \cdots, v_{k,N})| = |z_k(v_{k,1}, \cdots, v_{k,i}+\Delta v, \cdots, v_{k,N})| - |z_k(v_{k,1}, \cdots, v_{k,i}, \cdots, v_{k,N})|$$

である。

【００９１】上記数４６において、Δvは摂動のための微少項であり、上記数３４及び数３５におけるμ_vとμ_wはそれぞれ、移相器３－１乃至３－Ｎの制御電圧と、可変増幅器７２－０乃至７２－（Ｌ－１）の増幅度であるタップ係数のステップサイズである。本実施形態に係る時空間信号処理Ｍ－ＣＭＡ法のアルゴリズムを正しい収束させるには、この２種類のステップサイズは以下の条件を満足する必要がある。

【００９２】

【数３７】$\mu_w = \mu_v \Delta v$

ここで、Δvの単位はラジアンである。

【００９３】以上説明したように、本実施形態によれば、ポリフェーズフィルタバンクである時分割フィルタバンク回路１０を用いることにより、処理すべき信号のレートを低下させかつ各アンテナ素子に対応する複数の摂動項の信号を正確に取り出すことができる。従って、ビットレートに比較して非常に高速なサンプリングを行えるＡ／Ｄ変換器を必要とせず、低速となるのでサンプリングのタイミング調整も容易となる。それ故、回路構成が簡単であって、時間的正確にかつ、ビーム形成方向として正確に主ビームの制御やヌルの制御ができる。

【００９４】<第２の変形例>図７は、第２の実施形態の変形例である、本発明に係る第２の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｔａの構成を示すブロック図であり、図５及び図６と同一のものは同一の符号を付している。

【００９５】第２の実施形態においては、Ｍ個のＴＲＦ回路６１－０乃至６１－（Ｍ－１）を時分割フィルタバンク回路１０とビーム制御部２１ｔとの間に備えていたが、これに代えて、ビーム制御部２１ｔで指定される重み係数を有する１個のＴＲＦ回路６１をＡ／Ｄ変換器９と、時分割フィルタバンク回路１０との間に挿入したことを特徴としている。ここで、ビーム制御部２１ｔは、時空間信号処理Ｍ－ＣＭＡ法によるビーム制御処理において、利得制御前のベースバンド信号$y_{k,0}$（図５のベースバンド信号$\Psi_{k,0}$）を必要とするが、これは、図７の時分割フィルタバンク回路１０から出力されるベースバンド信号$\Psi_{k,0}$を重み付け係数で除算することにより計算することができる。また、これにとって代わって、図７において１点鎖線で示すように、Ａ／Ｄ変換器９からのベースバンド信号u_kから利得制御前のベースバンド信号$y_{k,0}$（図７のベースバンド信号$\Psi_{k,0}$）を時分割分離して取り出してもよい。

【００９６】以上のように構成された第２の変形例によれば、第２の実施形態における作用効果に加えて、ＴＲＦ回路６１の個数を大幅に減少させることができ、これにより、回路構成をより簡単にできるという特有の効果を有する。

【００９７】<第３の実施形態>図８は、本発明に係る第３の実施形態であるアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｍの構成を示すブロック図であり、図１乃至図７及び図１０と同一のものについては同一の符号を付している。本実施形態のアレーアンテナの制御装置は、ビーム制御部２１ｍを有するビーム制御回路２０ｍを備えたことを特徴としている。

【００９８】ビーム制御回路２０ｍは、復調器７及び時分割フィルタバンク回路１０を介してＡ／Ｄ変換器９からの出力信号であるベースバンド信号$\Psi_{k,m}$（$m=0, 1, 2, \cdots, M-1$）に基づいて、詳細後述する変形された最小平均二乗法（以下、Ｍ－ＬＭＳ法という。）を用いて、可変移相器３－１乃至３－Ｎの各移相量を摂動付加回路３０を制御することによりそれぞれ所定のシフト量だけ摂動させ、各移相量に対する、可変増幅器８２－０乃至８２－（Ｍ－１）から出力されるベースバンド信号$y_{k,m}$の摂動前後の変化量$\Delta y_{k,m}$を計算し、計算された変化量$\Delta y_{k,m}$と、Ａ／Ｄ変換器９から時分割フィルタバンク回路１０を介して出力されるベースバンド信号$\Psi_{k,0}$と、可変増幅器８２から出力されるベースバンド信号$y_{k,m}$と、ベースバンド信号$\Psi_{k,0}$を可変増幅器８２により利得制御されたベースバンド信号$y_{k,0}$とそれの符号判別値d_k（符号判別器８３の出力である。）との間の誤差信号e_kとに基づいて、当該誤差信号e_kの自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得g_kを計算してそれぞれ各可変移相器３－１乃至３－Ｎ及び可変増幅器８２－０乃至８２－（Ｍ－１）に出力することを特徴としている。

【００９９】ビーム制御回路２０ｍは、ビーム制御部２１ｍと、可変増幅器８２－０乃至８２－（Ｍ－１）と、

符号判別器８３と、減算器８４とを備えて構成される。ここで、各可変増幅器８２－０乃至８２－（Ｍ－１）は、入力されるベースバンド信号$\Psi_{k,m}$を、ビーム制御部８１により示される制御利得g_kで増幅して、利得制御されたベースバンド信号$y_{k,m}$をビーム制御部２１ｍに出力し、また、そのうちベースバンド信号$y_{k,0}$を符号判別器８３、減算器８４及びビーム制御部２１ｍに出力する。次いで、符号判別器８３は、後述するように、入力されるベースバンド信号y_kの符号判別値d_kを演算して減算器８４に出力する。さらに、減算器８４は、符号判別値d_kからベースバンド信号$y_{k,0}$を減算して減算結果の誤差信号e_kをビーム制御部８１に出力する。そして、ビーム制御部８１は、入力されるベースバンド信号$\Psi_{k,0}$及び$y_{k,m}$、並びに誤差信号e_kに基づいてＭ－ＬＭＳ法を用いて制御利得g_kを演算して可変増幅器８２に出力するとともに、可変制御電圧$v_{k,i}$（ｉ＝１，２，…，Ｎ）を演算してそれぞれ可変移相器３－１乃至３－Ｎに出力する。

【０１００】このビーム制御回路８０では、Ａ／Ｄ変換後のベースバンド信号Ψ_kのみに基づいて、Ｍ－ＬＭＳ法を用いて、例えば、データ伝送を行う前の所定のトレーニング期間において、各可変移相器３－１乃至３－Ｎに対する各移相制御電圧$v_{k,i}$を摂動付加回路３０を制御することにより所定のシフト量だけ摂動させることにより、各移相量に対する、可変増幅器８２から出力されるベースバンド信号$y_{k,m}$の摂動前後の変化量$\Delta y_{k,m}$を計算し、計算された変化量$\Delta y_{k,m}$と、Ａ／Ｄ変換器９から時分割フィルタバンク回路１０を介して出力されるベースバンド信号$\Psi_{k,0}$と、可変増幅器８２－０乃至８２－（Ｍ－１）から出力されるベースバンド信号$y_{k,m}$と、ベースバンド信号$y_{k,0}$の符号判別値d_k（符号判別器８３の出力である。）とベースバンド信号$y_{k,0}$との間の誤差信号e_kとに基づいて、当該誤差信号e_kの自乗平均が最小となるように、上記アレーアンテナの主ビームを所定の方向に向けるための上記各移相量及び上記利得を計算してそれぞれ各可変移相器３－１乃至３－Ｎ及び可変増幅器８２－０乃至８２－（Ｍ－１）に出力する。

【０１０１】以上のように構成されたアレーアンテナの制御装置においては、ビーム制御回路２０ｍは、ビーム制御回路２０ｍの減算器８４で発生される誤差信号e_kの自乗平均が最小となるように、アレーアンテナ１００の主ビームを適応的に所定の方向に形成する。構成されたアレーアンテナの制御装置では、低雑音増幅器２－１乃至２－Ｎ及び可変移相器３－１乃至３－Ｎは、アンテナ素子１－１乃至１－Ｎの素子数Ｎに対応したＮ個を必要とするが、合成器４以降の回路では、各回路構成要素は１つのみで済む。従って、図１０に示す従来例に比較して、ハードウエア構成が簡単であって、回路構成要素の数が少ないので消費電力が少ない。

【０１０２】次いで、ビーム制御回路２０ｍにおける制御アルゴリズムについて説明する。まず、可変増幅器８２－０乃至８２－（Ｍ－１）から出力される利得制御されたベースバンド信号$y_{k,m}$は次式で表される。

【０１０３】

【数３８】$y_{k,m}=g_k\Psi_{k,m}$

【０１０４】ここで、$\Psi_{k,m}$はＡ／Ｄ変換器９から時分割フィルタバンク回路１０を介して出力され複素数で表されたベースバンド信号であり、g_kは実数で表された可変増幅器８２－０乃至８２－（Ｍ－１）の利得であり、$y_{k,m}$は複素数で表された可変増幅器８２－０乃至８２－（Ｍ－１）の各出力信号を示している。このとき、誤差信号e_kを次式のように定義される。

【０１０５】

【数３９】$e_k=d_k-y_{k,0}$

【０１０６】ここで、d_kは符号判別器８３からの、符号判別値を示す出力信号であり、次式のように求められる。

【０１０７】

【数４０】$d_k=\mathrm{sgn}[\mathrm{Re}(y_k)]+j\cdot\mathrm{sgn}[\mathrm{Im}(y_k)]$

【０１０８】ここで、Ｒｅ［・］は引数の実数を示す関数であり、Ｉｍ［・］は引数の虚数を示す関数である。また、ｓｇｎ［ｘ］は符号判別関数であり、以下のように定義される。

【０１０９】

【数４１】ｓｇｎ［ｘ］
＝１；ｘ≧０のとき
＝－１；ｘ＜０のとき

【０１１０】この時、各可変増幅器８２－０乃至８２－（Ｍ－１）の利得は次式のように更新される。

【０１１１】

【数４２】$g_k=g_{k-1}+\mu\mathrm{Re}[\Psi_{k,0}e_k^*]$

【０１１２】ここで、μはステップサイズパラメータと呼ばれ、０＜μ＜１での適当な定数である。また、＊は複素共役を示す。一方、可変位相器３－ｉの制御電圧は次式のように更新される。

【０１１３】

【数４３】$v_{k,i}=v_{k-1,i}+\mu\mathrm{Re}(e_k^*\Delta y_{k,i})$

【０１１４】このとき、変化量$\Delta y_{k,i}$は次式のように求められる。

【０１１５】

【数４４】$\Delta y_{k,i}$
$=y_{k,0}(v_{k-1,1},\ \cdots,\ v_{k-1,i}+\Delta v,\ \cdots,\ v_{k-1,N})$
$-y_{k,0}(v_{k-1,1},\ \cdots,\ v_{k-1,i},\ \cdots,\ v_{k-1,N})$

【０１１６】数４４の右辺の第２項は、摂動電圧を付加しないときの時刻ｋ－１の移相制御電圧$v_{k-1,1}$，…，$v_{k-1,i}$，…，$v_{k-1,N}$を各可変移相器３－１乃至３－Ｎに印加したときの利得制御されたベースバンド信号y_kを示す。また、数４４の右辺の第１項は、時刻ｋ－１の

移相制御電圧$v_{k-1,1}$，…，$v_{k-1,i}$，…，$v_{k-1,N}$に加えて、第ｉ番目のアンテナ素子１−ｉに対応する可変移相器３−ｉのみに摂動電圧Δｖを余分にかけたときの利得制御されたベースバンド信号$y_{k,0}$を示す。そして、数４４で表される$\Delta y_{k,i}$はこれら２つの信号の変化量、すなわち、摂動前後のベースバンド信号$y_{k,0}$の変化量である。

【０１１７】従って、数４３から明らかなように、計算した摂動前後のベースバンド信号$y_{k,0}$の変化量$\Delta y_{k,i}$と、誤差信号e_kとに基づいて移相制御電圧$v_{k,i}$を演算して設定する。そして、数４２から明らかなように、誤差信号e_kの自乗平均が最小となるように、可変増幅器８２−０乃至８２−（Ｍ−１）の利得g_kを決定して設定する。このようにビーム制御することにより、当該アレーアンテナの主ビームを所定の方向に向けることができ、特に、ＴＤＭＡ等で利用されるプリアンブルやＣＤＭＡ等で利用されるパイロット信号を所望信号として用いることで、搬送波対干渉波電力比（ＣＩＲ）がマイナス、すなわち、所望信号が干渉波よりもレベルが低い場合にも、所望波方向にビームを向け、干渉波方向にヌルを形成できる。

【０１１８】本実施形態においては、振幅制御は、Ａ／Ｄ変換器９から時分割フィルタバンク回路１０を介した出力ベースバンド信号$y_{k,m}$に対してディジタル信号処理により行い、マイクロ波帯（ＲＦ帯）の可変移相器制御では、移相器入力信号を観測できないため、摂動により係数の更新量を求める。また、振幅制御では、出力ベースバンド信号$y_{k,m}$がディジタル信号として得られるため、数４２の形式で、振幅推定アルゴリズムが得られる。また、発明したアルゴリズムは誤差信号e_kの二乗平均の最小化という公知のＬＭＳ法と同様の規範を用いているため、発明したアルゴリズムを「Ｍ−ＬＭＳ法」と呼んでいる。

【０１１９】以上説明したように、本実施形態によれば、Ｍ−ＬＭＳ法を用いてビーム制御するので、ＤＢＦ回路で実現されたアダプティブアレーと同様に、ビーム、ヌル制御が可能で有ることに加えて、ＲＦ帯でビーム形成が行えるため、従来例に比較して回路規模やコストの削減が可能になるという利点がある。従って、構成が簡単であって消費電力が少ない。また、ＴＤＭＡ等で利用されるプリアンブルやＣＤＭＡ等で利用されるパイロット信号を所望信号として用いることで、搬送波対干渉波電力比（ＣＩＲ）がマイナス、すなわち、所望信号が干渉波よりもレベルが低い場合にも、所望波方向にビームを向け、干渉波方向にヌルを形成できる。従って、劣悪な環境であっても安定に適応動作を行うことができる。

【０１２０】また、本実施形態によれば、ポリフェーズフィルタバンクである時分割フィルタバンク回路１０を用いることにより、処理すべき信号のレートを低下させかつ各アンテナ素子に対応する複数の摂動項の信号を正確に取り出すことができる。従って、ビットレートに比較して非常に高速なサンプリングを行えるＡ／Ｄ変換器を必要とせず、低速となるのでサンプリングのタイミング調整も容易となる。それ故、回路構成が簡単であって、時間的正確にかつ、ビーム形成方向として正確に主ビームの制御やヌルの制御ができる。

【０１２１】<第３の変形例>図９は、第３の実施形態の変形例である、本発明に係る第３の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｍａの構成を示すブロック図であり、図８と同一のものは同一の符号を付している。

【０１２２】第３の実施形態においては、可変増幅器８２−０乃至８２−（Ｍ−１）を時分割フィルタバンク回路１０とビーム制御部２１ｍとの間に備えていたが、これに代えて、ビーム制御部２１ｍで指定される重み係数を有する１個の可変増幅器８２をＡ／Ｄ変換器９と、時分割フィルタバンク回路１０との間に挿入したことを特徴としている。ここで、ビーム制御部２１ｍは、Ｍ−ＬＭＳ法によるビーム制御処理において、利得制御前のベースバンド信号$y_{k,0}$（図８のベースバンド信号$\Psi_{k,0}$）を必要とするが、これは、図９の時分割フィルタバンク回路１０から出力されるベースバンド信号$\Psi_{k,0}$を制御利得g_kで除算することにより計算することができる。また、これにとって代わって、図９において１点鎖線で示すように、Ａ／Ｄ変換器９からのベースバンド信号u_kから利得制御前のベースバンド信号$y_{k,0}$（図９のベースバンド信号$\Psi_{k,0}$）を時分割分離して取り出してもよい。

【０１２３】以上のように構成された第３の変形例によれば、第３の実施形態における作用効果に加えて、可変増幅器８２の個数を大幅に減少させることができ、これにより、回路構成をより簡単にできるという特有の効果を有する。

【０１２４】<他の変形例>以上の実施形態においては、Ａ／Ｄ変換器９を用いてベースバンド信号をＡ／Ｄ変換した後、その後の回路においてディジタル信号処理を行っているが、Ａ／Ｄ変換器９を挿入せず、その後の回路においてアナログで信号処理を実行してもよい。

【０１２５】以上の実施形態においては、摂動付加回路３０は、各ビーム制御回路２０，２０ａ，２０ｔ，２０ｔａ，２０ｍ，２０ｍａとは別の回路で構成されているが、摂動付加回路３０の機能を各ビーム制御回路２０，２０ａ，２０ｔ，２０ｔａ，２０ｍ，２０ｍａ内においてソフトウエア又はハードウエア回路で統合して構成してもよい。

【０１２６】

【実施例】さらに、本発明者らは、第１の実施形態に係る、ポリフェーズフィルタを応用したＭ−ＣＭＡ法のアダプティブアレーの干渉抑圧特性を計算機シミュレーシ

ョンにより実験したので、その実験方法及び実験結果について以下に詳述する。

【０１２７】変調方式としてＱＰＳＫ変調方式を用い、検波器には遅延検波を適用した送受信機構成を前提とした。また，伝送路はＡＷＧＮ（Additive White Gaussian Noise）チャネルを適用した。アンテナは半波長間隔のリニアアレーアンテナで、その素子数は４とした。また、リニアアレーアンテナの正面方向を０度とすると、希望波は－５０度の方向から、干渉波は３０度の方向から等レベルで入射する環境を想定した。また、Ｍ－ＣＭＡ法の乗数をｐ＝ｑ＝１に設定し、ステップサイズμ＝０．０００１とした。処理速度の低減のためオーバサンプルはシンボルレートの４倍とした。また、アレーアンテナの初期状態は正面方向にビームを形成している。

【０１２８】図１１は、第１の実施形態のシミュレーション結果であって４素子リニアアレーアンテナの場合の指向性パターンを示すグラフである。図１１から明らかなように、希望波方向に理論限界の１２ｄＢ程度のアレーファクタを持つビームを形成している。干渉波方向には深いヌルを形成できていることがわかる。ただし，ＳＮＲが低い場合には、若干ヌルの位置がずれている。これは、ＳＮＲが低い場合には、ビームを形成する方に制御が集中し、ヌルには多少感度が落ちるためと考えられる。

【０１２９】図１２は、第１の実施形態のシミュレーション結果であって４素子リニアアレーアンテナの場合の搬送波／雑音電力比（ＣＮＲ）に対するビットエラーレート（ＢＥＲ）の特性を示すグラフである。図１２においては、理論値として、干渉がない条件での４素子最大比合成ダイバーシチ受信時の遅延検波の特性を示している。Ｍ－ＣＭＡ法を用いたアダプティブアレーは希望波にビームを向けるだけでなく干渉波方向に鋭いヌルを形成できるため、すべてのＣＮＲ条件において、理論値に１．５ｄＢにまで漸近する優れた特性が得られることが分かる。この１．５ｄＢの劣化は上述したヌルに対する感度低下によるものと考えられる。

【０１３０】以上説明したように、小型・低価格化が可能なアナログビーム形成型アダプティブアレーにおいて適応ビーム制御を可能とするＭ－ＣＭＡ法の効果的な実現方法として、ポリフェーズフィルタを利用した。原理的にＭ－ＣＭＡ法の係数更新式においては同時刻の「摂動項」と「非摂動項」が必要となる。この信号を簡易に得る方法として、ポリフェーズフィルタを構成する各フィルタバンクを備えた時分割フィルタバンク回路１０が同時刻に全く同じ波形を出力することを利用する。すなわち、時分割フィルタバンク回路１０内の各ポリフェーズフィルタには摂動を受けた信号と受けない信号を振り分けることで、フィルタ毎に異なった摂動あるいは、非摂動項が出力されるのである。

【０１３１】

【発明の効果】以上詳述したように本発明によれば、ポリフェーズフィルタバンクである時分割フィルタバンク回路を用いることにより、処理すべき信号のレートを低下させかつ各アンテナ素子に対応する複数の摂動項の信号を正確に取り出すことができる。従って、ビットレートに比較して非常に高速なサンプリングを行えるＡ／Ｄ変換器を必要とせず、低速となるのでサンプリングのタイミング調整も容易となる。それ故、回路構成が簡単であって、時間的正確にかつ、ビーム形成方向として正確に主ビームの制御やヌルの制御ができる。

【図面の簡単な説明】

【図１】　本発明に係る第１の実施形態であるアレーアンテナの制御装置の構成を示すブロック図である。

【図２】　図１の時分割フィルタバンク回路１０とビーム制御回路２０と摂動付加回路３０の詳細な内部構成を示すブロック図である。

【図３】　図２の時分割フィルタバンク回路１０の動作例を示すブロック図である。

【図４】　第１の実施形態の変形例である、本発明に係る第１の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ａの構成を示すブロック図である。

【図５】　本発明に係る第２の実施形態であるアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｔの構成を示すブロック図である。

【図６】　図５のＴＲＦ回路６１の詳細な内部構成を示すブロック図である。

【図７】　第２の実施形態の変形例である、本発明に係る第２の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｔａの構成を示すブロック図である。

【図８】　本発明に係る第３の実施形態であるアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｍの構成を示すブロック図である。

【図９】　第３の実施形態の変形例である、本発明に係る第３の変形例のアレーアンテナの制御装置における時分割フィルタバンク回路１０とビーム制御回路２０ｍａの構成を示すブロック図である。

【図１０】　従来例のアレーアンテナの制御装置の構成を示すブロック図である。

【図１１】　第１の実施形態のシミュレーション結果であって４素子リニアアレーアンテナの場合の指向性パターンを示すグラフである。

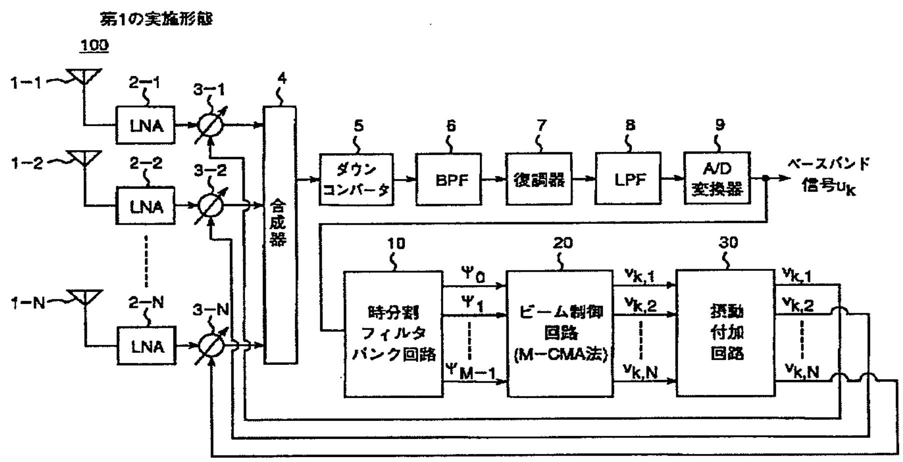
【図１２】　第１の実施形態のシミュレーション結果であって４素子リニアアレーアンテナの場合の搬送波／雑音電力比（ＣＮＲ）に対するビットエラーレート（ＢＥＲ）の特性を示すグラフである。

【符号の説明】

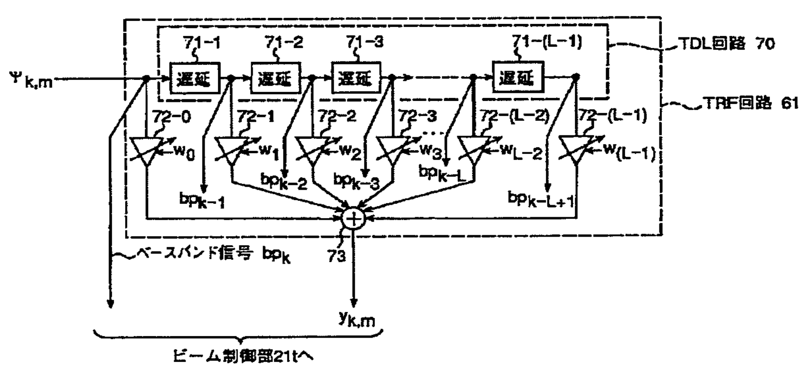
１－１乃至１－Ｎ…アンテナ素子、
２－１乃至２－Ｎ…低雑音増幅器（ＬＮＡ），
３－１乃至３－Ｎ…可変移相器、
４…合成器、
５…ダウンコンバータ、
６…帯域通過フィルタ（ＢＰＦ）、
７…復調器、
８…低域通過フィルタ（ＬＰＦ）、
９…Ａ／Ｄ変換器、
１０…時分割フィルタバンク回路、
１１－１乃至１１－（Ｍ－１）…遅延回路、
１２－０乃至１２－（Ｍ－１）…ダウンサンプラ、
１３－０乃至１３－（Ｍ－１）…ディジタルフィルタ、
１４－０乃至１４－（Ｍ－１）…ダウンサンプラ、
２０，２０ａ，２０ｔ，２０ｔａ，２０ｍ，２０ｍａ…ビーム制御回路、

＊２１，２１ｔ，２１ｍ…ビーム制御部、
２２－０乃至２２－（Ｍ－１）…可変増幅器、
２３…基準信号発生器、
２４…減算器、
３０…摂動付加回路、
３１…摂動付加電圧発生器、
３２…スイッチコントローラ、
３３－１乃至３３－Ｎ…加算器、
３４－１乃至３４－Ｎ…スイッチ、
６１，６１－０乃至６１－（Ｍ－１）…トランスバーサルフィルタ回路（ＴＲＦ回路）、
７０…ＴＤＬ回路、
７１－１乃至７１－（Ｌ－１）…遅延回路、
７２－０乃至７２－（Ｌ－１）…可変増幅器、
７３…加算器、
＊　１００…アレーアンテナ。

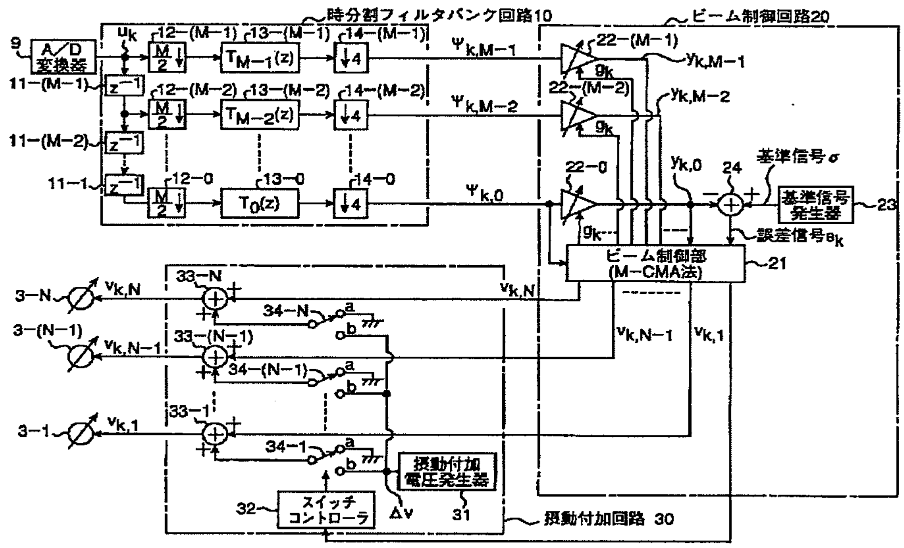
【図１】



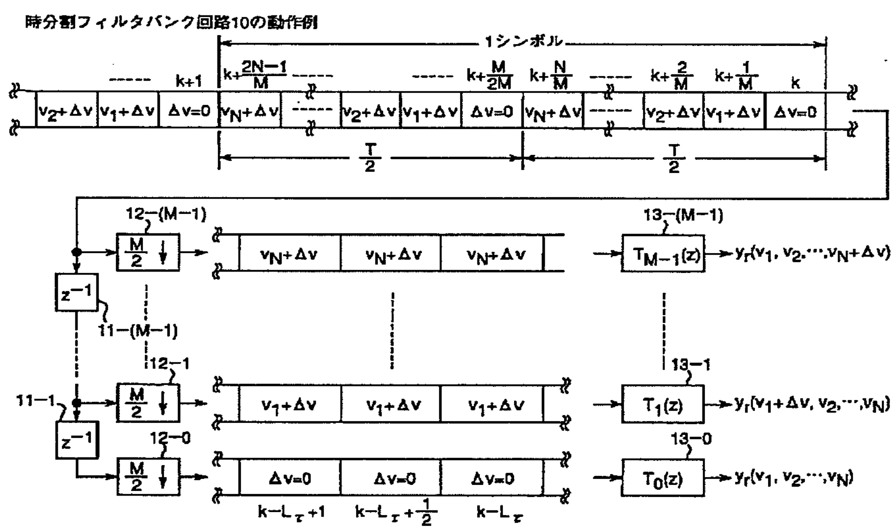
【図６】



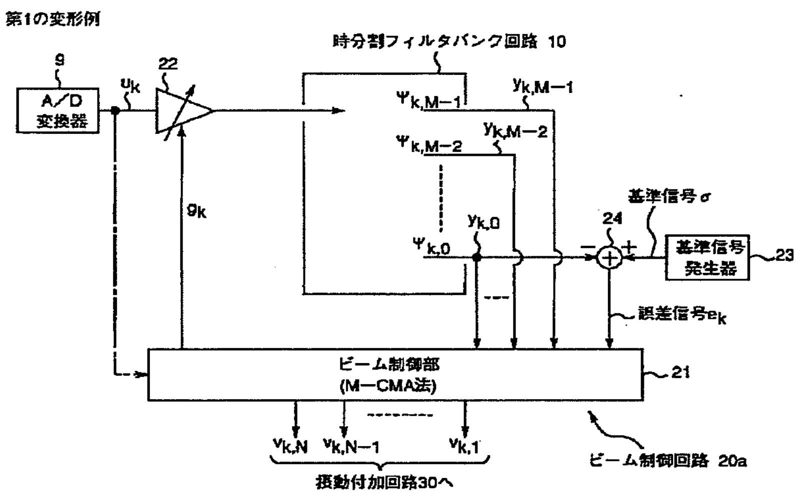
【図２】


時分割フィルタバンク回路10
ビーム制御回路20
A/D 変換器
ビーム制御部 (M−CMA法)
基準信号σ
基準信号発生器
誤差信号e_k
摂動付加電圧発生器
スイッチコントローラ
摂動付加回路 30

【図３】

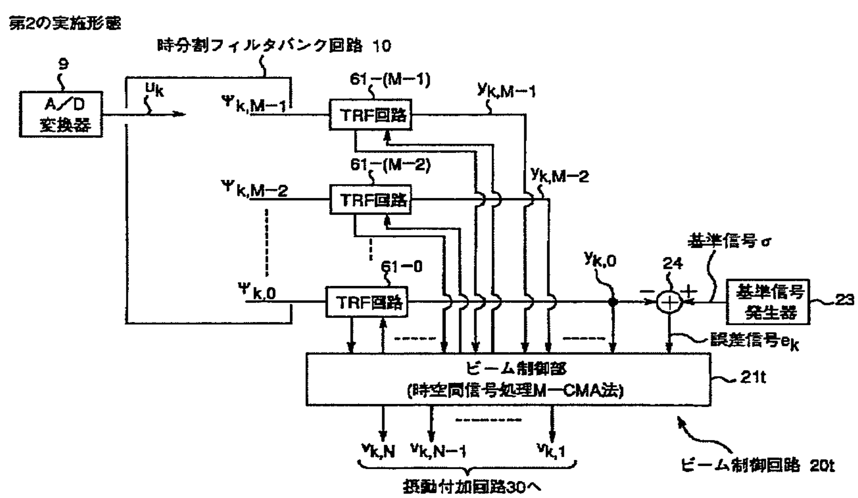

時分割フィルタバンク回路10の動作例
1シンボル

【図４】



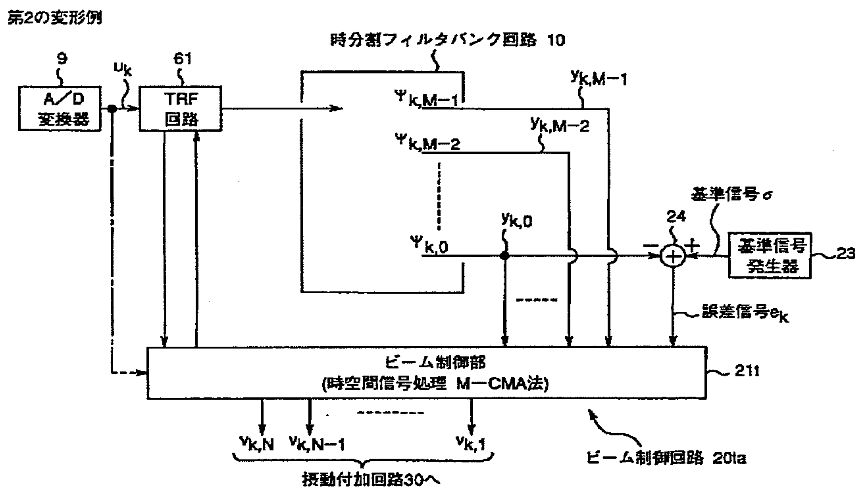
第1の変形例
時分割フィルタバンク回路 10
9
A/D
変換器
u_k
22
g_k
$\Psi_{k,M-1}$
$y_{k,M-1}$
$\Psi_{k,M-2}$
$y_{k,M-2}$
$\Psi_{k,0}$
$y_{k,0}$
基準信号σ
24
基準信号
発生器
23
誤差信号e_k
ビーム制御部
(M−CMA法)
21
$v_{k,N}$
$v_{k,N-1}$
$v_{k,1}$
摂動付加回路30へ
ビーム制御回路 20a

【図５】

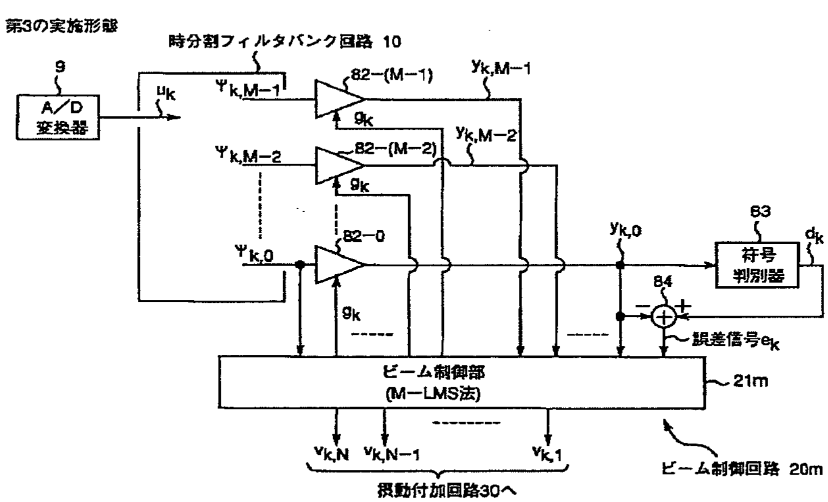


第2の実施形態
時分割フィルタバンク回路 10
9
A/D
変換器
u_k
$\Psi_{k,M-1}$
61−(M−1)
TRF回路
$y_{k,M-1}$
61−(M−2)
$\Psi_{k,M-2}$
TRF回路
$y_{k,M-2}$
基準信号σ
$y_{k,0}$
24
61−0
$\Psi_{k,0}$
TRF回路
基準信号
発生器
23
誤差信号e_k
ビーム制御部
(時空間信号処理M−CMA法)
21t
$v_{k,N}$
$v_{k,N-1}$
$v_{k,1}$
摂動付加回路30へ
ビーム制御回路 20t

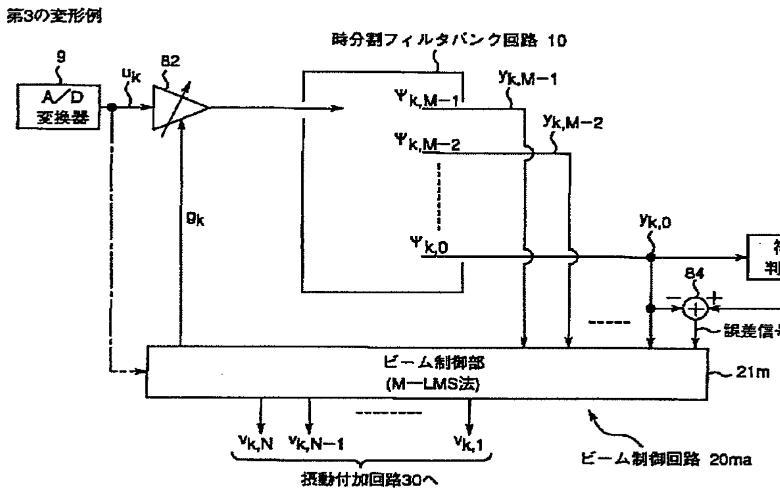
【図７】


第2の変形例
時分割フィルタバンク回路 10
9
A／D 変換器
u_k
61
TRF 回路
$\Psi_{k,M-1}$
$\Psi_{k,M-2}$
$\Psi_{k,0}$
$y_{k,M-1}$
$y_{k,M-2}$
$y_{k,0}$
基準信号σ
24
基準信号発生器
23
誤差信号e_k
ビーム制御部 (時空間信号処理 M－CMA法)
211
$v_{k,N}$ $v_{k,N-1}$ $v_{k,1}$
摂動付加回路30へ
ビーム制御回路 201a

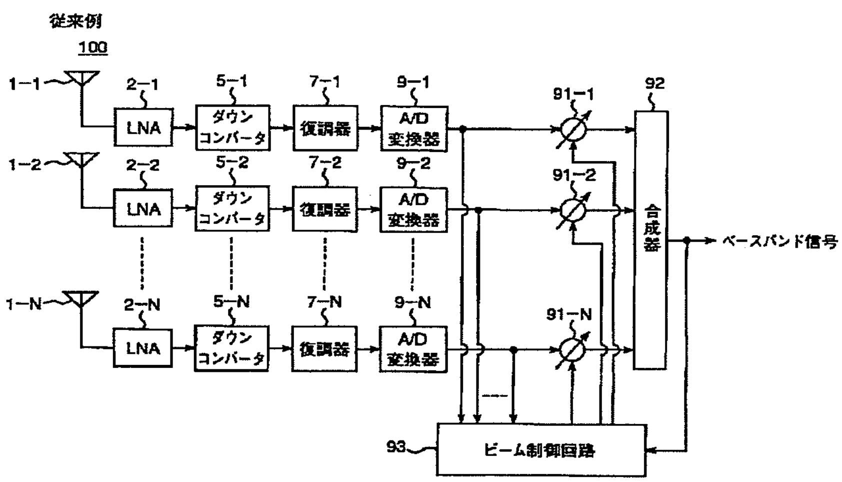
【図８】


第3の実施形態
時分割フィルタバンク回路 10
9
A／D 変換器
u_k
$\Psi_{k,M-1}$
$\Psi_{k,M-2}$
$\Psi_{k,0}$
82－(M－1)
82－(M－2)
82－0
g_k
$y_{k,M-1}$
$y_{k,M-2}$
$y_{k,0}$
83
符号判別器
d_k
84
誤差信号e_k
ビーム制御部 (M－LMS法)
21m
$v_{k,N}$ $v_{k,N-1}$ $v_{k,1}$
摂動付加回路30へ
ビーム制御回路 20m

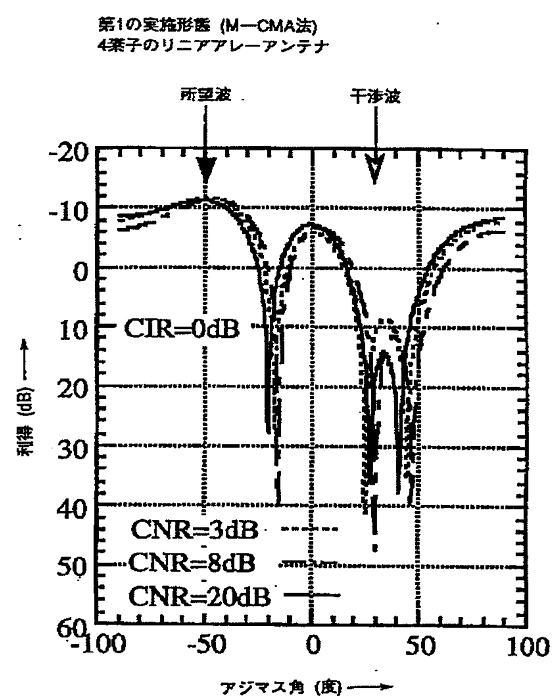
【図９】


第3の変形例
9
A/D 変換器
u_k
82
時分割フィルタバンク回路 10
$\Psi_{k,M-1}$
$y_{k,M-1}$
$\Psi_{k,M-2}$
$y_{k,M-2}$
g_k
$\Psi_{k,0}$
$y_{k,0}$
83
符号 判別器
d_k
84
誤差信号e_k
ビーム制御部 (M—LMS法)
21m
$v_{k,N}$ $v_{k,N-1}$ $v_{k,1}$
摂動付加回路30へ
ビーム制御回路 20ma

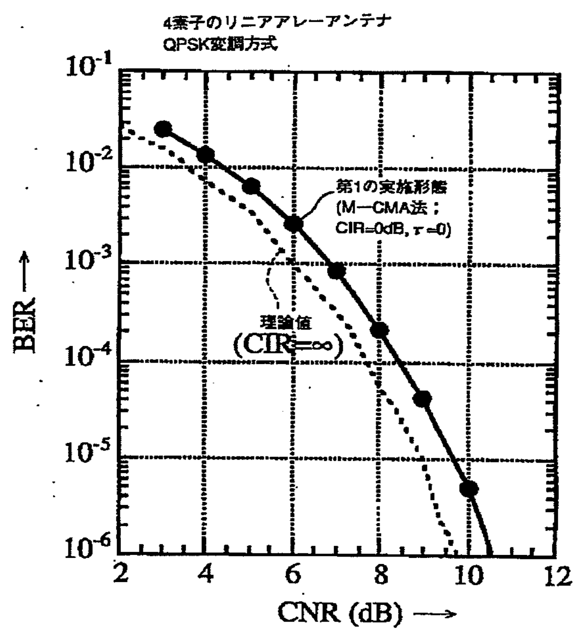
【図１０】


従来例
100
1−1
1−2
1−N
2−1
2−2
2−N
LNA
5−1
5−2
5−N
ダウン コンバータ
7−1
7−2
7−N
復調器
9−1
9−2
9−N
A/D 変換器
91−1
91−2
91−N
92
合成器
ベースバンド信号
93
ビーム制御回路

【図１１】



【図１２】



フロントページの続き

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Ｆターム(参考)　5J021 AA05 AA06 CA06 DB02 DB03 DB04 EA04 FA05 FA14 FA15 FA16 FA17 FA20 FA23 FA24 FA26 FA29 FA30 FA31 FA32 GA02 HA05 HA10
5K059 CC03 CC04 DD37 EE02

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JAPANESE [JP,2002-076747,A]

[Translation done.]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain control of the baseband signaling outputted from the above-mentioned recovery means, and to output it on predetermined gain, A subtraction means to generate and output the error signal between the baseband signaling outputted from the above-mentioned gain control means, and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. So that the dip vector of the power of the error signal outputted from the above-mentioned subtraction means over each amount of phase shifts may be calculated and the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control unit of the array antenna equipped with the control means which calculates the gain of each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the above-mentioned gain control means, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, The control unit of the array antenna characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-sharing processing so that it may be outputted as an output signal.
[Claim 2] The above-mentioned gain control means is the control unit of the array antenna according to claim 1 characterized by being a transversal filter circuit.
[Claim 3] two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain

control of the baseband signaling outputted from the above-mentioned recovery means, and to output it on predetermined gain, A sign distinction means to output the sign distinction value signal which distinguishes the sign of the baseband signaling outputted from the above-mentioned gain control means, and shows a sign distinction value, A subtraction means to generate and output the error signal between the sign distinction value signal outputted from the above-mentioned sign distinction means, and the baseband signaling outputted from the above-mentioned gain control means, The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before and behind the perturbation of the baseband signaling outputted from the above-mentioned gain control means to each amount of phase shifts, and was calculated, Based on the baseband signaling outputted from the above-mentioned recovery means, the baseband signaling outputted from the above-mentioned gain control means, and the error signal outputted from the above-mentioned subtraction means, so that the root mean square of the above-mentioned error signal may serve as min It has the control means which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, The control unit of the array antenna characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-sharing processing so that it may be outputted as an output signal.
[Claim 4] The control unit of the array antenna which is inserted and formed in the latter part of the above-mentioned recovery means in the control unit of claim 1 thru/or the array antenna of one of 3 publications, carries out analog-to-digital conversion to the baseband signaling outputted from the above-mentioned recovery means, and is characterized by having further a conversion means to output the digital baseband signaling after conversion.
[Claim 5] two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals using two or more phase shift means with the step to which the phase shift only of the predetermined amount of phase shifts is carried out, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which generates the error signal between the baseband signaling by which gain control was carried out [above-mentioned], and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. Calculate the dip vector of the power of the above-mentioned error signal over each amount of phase shifts, and so that the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control approach of the array antenna containing the step which calculates each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the gain of the above-mentioned step which carries out gain control, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate

the above-mentioned step which carries out gain control, the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, The control approach of the array antenna characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.
[Claim 6] The above-mentioned step which carries out gain control is the control approach of the array antenna according to claim 1 characterized by performing using a transversal filter circuit.
[Claim 7] two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals with the step to which the phase shift only of the predetermined amount of phase shifts is carried out using two or more phase shift means, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which outputs the sign distinction value signal which distinguishes the sign of the baseband signaling by which gain control was carried out [above-mentioned], and shows a sign distinction value, The step which generates the error signal between the above-mentioned sign distinction value signal and the baseband signaling by which gain control was carried out [above-mentioned], The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before and behind the perturbation of the baseband signaling by which gain control was carried out [above-mentioned] to each amount of phase shifts, and was calculated, Based on the baseband signaling by which the recovery was carried out [above-mentioned], the baseband signaling by which gain control was carried out [above-mentioned], and the above-mentioned error signal, so that the root mean square of the above-mentioned error signal may serve as min It has the step which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate the above-mentioned step which carries out gain control, the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, The control approach of the array antenna characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.
[Claim 8] The control approach of the array antenna which is performed after the above-mentioned step which carries out a recovery, carries out analog-to-digital conversion to the baseband signaling by which the recovery was carried out [above-mentioned], and is characterized by including further the step which outputs the digital baseband signaling after conversion in the control approach of claim 5 thru/or the array antenna of one of 7 publications.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the control unit and the control approach for controlling the array antenna equipped with two or more antenna elements.
[0002]
[Description of the Prior Art] Drawing 10 is the block diagram showing the configuration of the control device of the array antenna of the conventional example. A radio signal is received in drawing 10 by the array antenna 100 by which it comes to juxtapose two or more the antenna elements 1-1 thru/or 1-N of N individual on 1 straight line at the predetermined spacing mutually. The radio signal received by each antenna element 1-1 thru/or 1-N, respectively A low noise amplifier (LNA) 2-1 thru/or 2-N, the down converter 5-1 that carries out frequency conversion to the intermediate frequency signal of a predetermined intermediate frequency, or 5-N, It is outputted to the beam control circuit 93 and a variable phase-shifter 91-1 thru/or 91-N through A/D converter 9-1 thru/or 9-N which performs the demodulator 7-1 thru/or 7-N and the analog / digital conversion which restores to an intermediate frequency signal to baseband signaling. A variable phase-shifter 91-1 thru/or 91-N output the baseband signaling inputted to the synthetic vessel 92, after carrying out the phase shift only of the amount of phase shifts in which it is directed from the beam control circuit 93, respectively. The synthetic vessel 92 is outputted to an external device while it carries out power composition of the baseband signaling of a two or more N individual inputted and outputs the baseband signaling after composition to the beam control circuit 93.
[0003] Each baseband signaling into which the beam control circuit 93 is inputted from A/D converter 9-1 thru/or 9-N here, Adaptation beam control algorithms, such as technique based on the criteria of MMSE (Minimizing Mean Square Error), such as law, are used. the baseband signaling after composition -- being based -- for example, well-known LMS (Least Mean Square) -- It outputs in order for the baseband signaling after composition to serve as max, and to calculate each amount of phase shifts of the variable phase-shifter 91-1 by which an array antenna 100 turns the main beam in the predetermined direction thru/or 91-N and to control each variable phase-shifter 91-1 thru/or 91-N.
[0004] The so-called control device of the ecad array antenna constituted as mentioned above is highly efficient antenna control equipment which can obtain the directivity response pattern which was adapted for the received electric-wave environment by combining with two or more antenna elements 1-1 thru/or 1-N, and radio set circuits the variable phase-shifter 91-1 which is a digital-signal-processing circuit thru/or 91-N, the synthetic vessel 92, and the beam control circuit 93. the configuration which used the digital beam formation circuit (DBF) in the conventional example of drawing 10 -- it is -- forming the main beam of an array antenna in the direction of a request incoming wave **** -- the direction of an interference wave -- null -- it has the function to form a point and to remove this.
[0005] However, since A/D converter 9-1 thru/or 9-N needed to be used for the receiving-circuit (low noise amplifier 2-1 thru/or 2-N, down converter 5-1 or 5-N and demodulator 7-1 thru/or 7-N) list for every antenna element 1-1 thru/or 1-N, there was a trouble that hardware

magnitude and power consumption became large. Especially, when it is a high interest profit antenna with many element numbers of an antenna element, especially this problem will become serious. Furthermore, since it receives for every antenna element, there is also a fault that actuation becomes difficult under the environment to which signal level fell.

[0006] In order to solve this trouble, this invention persons "For example, the conventional technical reference 1 "M-CMA besides Tano (Modified Constant Modulus Algorithm), - In digital-signal-processing algorithm-" for adaptation beam shape ** by microwave signal processing, the Institute of Electronics, Information and Communication Engineers research report and A-P 99-62, and pp.15 1999 [-22 or]" M-CMA (ModifiedConstant Modulus Algorithm) is proposed as adaptation algorithm suitable for the adaptive array which performs beam shape ** with this microwave band, and performs digital-signal-processing control. By this M-CMA method, it is premised on constituting a beam formation machine from a variable phase-shifter and an adder for simplification of a hardware configuration. in order that the M-CMA method may make a valuation basis minimization of the average square error of amplitude deflection like the CMA method -- the CMA method -- the same -- beam steering and null -- the concurrency control of a steering is possible. Needless to say, since it is positioned in a blind algorithm, before the M-CMA method establishes frame synchronization, and a frequency and phase simulation, beam formation is possible for it. Therefore, beam shape ** is performed before various synchronous establishment, and from a beam formation machine, since the high signal of SINR (Signal to Interference and NoiseRatio) is supplied after IF stage, various synchronizations also have the advantage of being easily establishable, under the inferior SINR environment. The M-CMA method presumes the dip vector in the error flat surface over the control voltage of each variable phase-shifter using a perturbation theoretically.

[0007]

[Problem(s) to be Solved by the Invention] However, by the M-CMA method, the output signal (perturbation term) of the beam formation machine when giving a perturbation to the input signal of the same time of day and the output signal (non-precessing term) of the beam formation machine which is not given are needed in an updating type. There is an approach using a high-speed sampling as a means to ask for this in approximation. This samples the output signal of a beam formation machine at a high speed to a symbol rate, and uses the signal with which this output adjoined each other as "a non-precessing term" and a "perturbation term" at the same time it applies a perturbation. If the effect of a noise is disregarded, correlation of the signal with which the output signal of the beam formation machine by which the high-speed sample was carried out adjoined each other will be dramatically high to this principle of operation, and it will use that the difference among both is only a difference in the existence of a perturbation for it. However, there was a trouble that the A/D converter which can perform a very high-speed sampling in this case as compared with a bit rate being needed, and sampling timing adjustment were difficult, and circuitry became complicated.

[0008] The object of this invention solves the above trouble and it is in offering the control unit and the control approach of an array antenna as for which control of the main beam and control of null are made to accuracy as a beam formation direction in time [as compared with the conventional example, a configuration is easy, and].

[0009]

[Means for Solving the Problem] the control unit of the array antenna concerning this invention -- two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain control of the baseband signaling outputted from the above-mentioned recovery means, and to output it on predetermined gain, A subtraction means to generate and output the error signal between the

baseband signaling outputted from the above-mentioned gain control means, and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. So that the dip vector of the power of the error signal outputted from the above-mentioned subtraction means over each amount of phase shifts may be calculated and the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control unit of the array antenna equipped with the control means which calculates the gain of each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the above-mentioned gain control means, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-sharing processing so that it may be outputted as an output signal.
[0010] In the control device of the above-mentioned array antenna, the above-mentioned gain control means is preferably characterized by being a transversal filter circuit.
[0011] Moreover, the control unit of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain control of the baseband signaling outputted from the above-mentioned recovery means, and to output it on predetermined gain, A sign distinction means to output the sign distinction value signal which distinguishes the sign of the baseband signaling outputted from the above-mentioned gain control means, and shows a sign distinction value, A subtraction means to generate and output the error signal between the sign distinction value signal outputted from the above-mentioned sign distinction means, and the baseband signaling outputted from the above-mentioned gain control means, The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before and behind the perturbation of the baseband signaling outputted from the above-mentioned gain control means to each amount of phase shifts, and was calculated, Based on the baseband signaling outputted from the above-mentioned recovery means, the baseband signaling outputted from the above-mentioned gain control means, and the error signal outputted from the above-mentioned subtraction means, so that the root mean square of the above-mentioned error signal may serve as min It has the control means which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-

sharing processing so that it may be outputted as an output signal.
[0012] Preferably, the control unit of the above-mentioned array antenna is inserted and formed in the latter part of the above-mentioned recovery means, carries out analog-to-digital conversion to the baseband signaling outputted from the above-mentioned recovery means, and is characterized by having further a conversion means to output the digital baseband signaling after conversion.
[0013] Furthermore, the control approach of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals using two or more phase shift means with the step to which the phase shift only of the predetermined amount of phase shifts is carried out, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which generates the error signal between the baseband signaling by which gain control was carried out [above-mentioned], and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. Calculate the dip vector of the power of the above-mentioned error signal over each amount of phase shifts, and so that the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control approach of the array antenna containing the step which calculates each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the gain of the above-mentioned step which carries out gain control, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate the above-mentioned step which carries out gain control, the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.
[0014] In the control approach of the above-mentioned array antenna, the above-mentioned step which carries out gain control is preferably characterized by performing using a transversal filter circuit.
[0015] Furthermore, the control approach of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals with the step to which the phase shift only of the predetermined amount of phase shifts is carried out using two or more phase shift means, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which outputs the sign distinction value signal which distinguishes the sign of the baseband signaling by which gain control was carried out [above-mentioned], and shows a sign distinction value, The step which generates the error signal between the above-mentioned sign distinction value signal and the baseband signaling by which gain control was carried out [above-mentioned], The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before

and behind the perturbation of the baseband signaling by which gain control was carried out [above-mentioned] to each amount of phase shifts, and was calculated, Based on the baseband signaling by which the recovery was carried out [above-mentioned], the baseband signaling by which gain control was carried out [above-mentioned], and the above-mentioned error signal, so that the root mean square of the above-mentioned error signal may serve as min It has the step which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate the above-mentioned step which carries out gain control, the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.

[0016] The control approach of the above-mentioned array antenna is preferably performed after the above-mentioned step which carries out a recovery, carries out analog-to-digital conversion to the baseband signaling by which the recovery was carried out [above-mentioned], and is characterized by including further the step which outputs the digital baseband signaling after conversion.

[0017]

[Embodiment of the Invention] Hereafter, the operation gestalt which starts this invention with reference to a drawing is explained.

[0018] <Operation gestalt of ** 1st> drawing 1 is the block diagram showing the configuration of the control device of the array antenna which is the 1st operation gestalt concerning this invention, and attaches the same sign about the same thing as drawing 10 . Moreover, drawing 2 is the block diagram showing the detailed internal configuration of the time-sharing filter bank circuit 10 of drawing 1 , the beam control circuit 20, and the perturbation addition circuit 30.

[0019] The control unit of the array antenna of this 1st operation gestalt The array antenna 100 (for example, it is a linear array and may be arranged in a two-dimensional configuration or a three-dimension configuration.) with which it comes to arrange two or more the antenna elements 1-1 thru/or 1-N of N individual at the predetermined spacing mutually In the adaptive control mold control unit equipped with the beam control circuit 20 for controlling a beam using the M-CMA method One signal in the period which it does not precess between A/D converter 9 and the beam control circuit 30 in the perturbation addition circuit 30 based on the baseband signaling inputted (at least one signal may be used.) It is characterized by having the time-sharing filter bank circuit 10 which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the M sequence signal which is a training signal in the period which it precessed in the perturbation addition circuit 30 differ. That is, since the time-sharing filter bank circuit 10 which consisted of this operation gestalt with a poliphase expression as an approach of solving the above-mentioned problem in the beam control which used the M-CMA method is used and the perturbation term and the non-precessing term in this time of day are acquired in a strict form by this, exact beam Nur control is enabled. Here, the digital filter 13-0 in the time-sharing filter bank circuit 10 thru/or 13- (M-1) carry out the poliphase configuration of the root roll-off filter used as a band limit filter for example, by the digital phase modulation system.

[0020] Hereafter, the configuration of the control unit of the array antenna shown in drawing 1 is explained. In drawing 1 , the radio signal which the radio signal was received and was received by each antenna element 1-1 thru/or 1-N by the array antenna 100 by which it comes to arrange two or more the antenna elements 1-1 thru/or 1-N of N individual at the predetermined spacing mutually is inputted into a variable phase-shifter 3-1 thru/or 3-N through a low noise amplifier (LNA) 2-1 thru/or 2-N, respectively. Each variable phase-shifter 3-1 thru/or 3-N output the

radio signal inputted to the synthetic vessel 4, after carrying out the phase shift only of each amount of phase shifts corresponding to each phase shift control voltage vk and i (i= 1, 2, --, N) outputted from the perturbation addition circuit 30, respectively. The synthetic vessel 4 outputs only the down converter 5 which carries out power composition of the radio signal of N individual inputted, and carries out frequency conversion of the radio signal after composition to the intermediate frequency signal of a predetermined intermediate frequency, and the band component of an intermediate frequency signal to a demodulator 7 through the band-pass filter (BPF) 6 which carries out band wave filtration. A demodulator 7 restores to the radio signal inputted to baseband signaling using the recovery approach corresponding to the modulation approaches by the side of a transmitter (for example, QPSK, PSK, FSK, etc.), and outputs it to A/D converter 9 through the low pass filter (LPF) 8 which takes out only desired baseband signaling. A/D converter 9 is boiled and outputted to the beam control circuit 20 through the time-sharing filter bank circuit 10 while it carries out A/D conversion of the baseband signaling of an analog inputted to digital baseband signaling and outputs the baseband signaling signal uk after conversion to an external device.
[0021] In addition, the microwave signal processor which becomes in well-known large-scale GaAsMMIC can constitute a variable phase-shifter 3-1 thru/or 3-N and the synthetic vessel 4, for example. Moreover, in this operation gestalt, baseband signaling sets the sampling rate of A/D converter 9 to fs=2Mfc for example, including an M sequence signal as a training signal. Here, M is the one or more natural numbers, and fc is a symbol clock frequency.
[0022] The delay circuit 11-1 thru/or 11- (M-1) of an individual which is mutually connected to concatenation and has the time delay of 1/(2Mfc), respectively as the time-sharing filter bank circuit 10 is shown in drawing 2 (M-1), M down samplers 12-0 thru/or 12- (M-1) which has a twice as many down sampling rate as this, respectively (M/2), M digital filters 13-0 thru/or 13- (M-1) which has the transfer function which carries out the detail after-mentioned, respectively, for example, consists of FIR filters, It has M down samplers 14-0 thru/or 14- (M-1) which has a twice as many down sampling rate as this, respectively (1/4), and is constituted. In the time-sharing filter bank circuit 10 the baseband signaling uk from A/D converter 9 While being outputted to the beam control circuit 20 through down sampler 12- (M-1), digital filter 13- (M-1), and down sampler 14- (M-1) as baseband signaling psik by which time-sharing processing was carried out, and M-1 It is outputted to the down sampler 12-0 through delay circuit 11- (M-1) of the individual (M-1) by which cascade connection was carried out mutually thru/or 11-1. Here, the baseband signaling uk outputted from delay circuit 11- (M-1) is outputted to the beam control circuit 20 through down sampler 12- (M-2), digital filter 13- (M-2), and down sampler 14- (M-2) as baseband signaling psik by which time-sharing processing was carried out, and M-2. baseband signaling psi by which time-sharing processing of the baseband signaling uk outputted from delay circuit 11-m was hereafter carried out similarly through down sampler 12-m, digital filter 13-m, and down sampler 14-m -- it outputs to the beam control circuit 20 as k and m -- having -- here -- m=M- it is 3, --, 0.
[0023] Drawing 3 is the block diagram showing the example of the time-sharing filter bank circuit 10 of drawing 2 of operation, and shows the case of N=M -1 as an example with this operation gestalt.
[0024] With this operation gestalt, as shown in drawing 3 , divide the time amount T of one symbol into two, and it sets to time amount T / 2. M sample signals (this corresponds an M sequence signal.) The sample signal of the 1st non-precessing term in the period to include and which does not precess M sample signals in the perturbation addition circuit 30 (deltav=0), The sample signal (perturbation addition electrical-potential-difference deltav was added) of the perturbation term of two or moreN (= M-1) individual within the M sequence signal which is a training signal in the period which it precessed in the perturbation addition circuit 30 is included. And the time-sharing filter bank circuit 10 performs time-sharing processing so that it may be outputted as an output signal with which the sample signal (deltav=0) of the 1st non-precessing term differs from the sample signal (perturbation addition electrical-potential-difference deltav was added) of M-1 perturbation term among M sample signals.
[0025] <A To HREF="/Tokujitu/tjitemdrw.ipdl?N0000=239&N0500=1 E_N/;>;?

898;8///&N0001=15&N0552=9&N 0553= 000020" TARGET="tjitemdrw"> drawing 2 Baseband signaling psik after the time-sharing processing which sets and is outputted from the time-sharing filter bank circuit 10, and 0 While being directly outputted to the beam control section 21, it is inputted into the beam control section 21 and a subtractor 24 through the adjustable amplifier 22-0 which has the control gain gk specified by the beam control section 21. moreover, baseband signaling [after the time-sharing processing outputted from the time-sharing filter bank circuit 10] psi -- k and m are inputted into the beam control section 21 through adjustable amplifier 22-m which has the control gain gk specified by the beam control section 21 -- having -- here -- m= -- it is 1, 2, --, M-1. Here, control gain can take a forward or negative value. On the other hand, the reference signal generator 23 generates the reference signal sigma which has predetermined constant value, and outputs it to a subtractor 24. A subtractor 24 subtracts the baseband signaling yk after gain magnification, and 0 from a reference signal sigma, and outputs the error (or deflection) signal ek to the beam control section 21. Based on the error signal ek inputted, M baseband signaling yk by which gain control was carried out, respectively, 0 or yk, M-1, and baseband signaling psik before gain control and 0, the beam control section 21 so that the detail after-mentioned may be carried out Control the switching controller 32 of the perturbation addition circuit 30, and only a predetermined shift amount is made to precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i (i= 1, 2, --, N) of 3-N using the M-CMA method. Make only a predetermined response shift amount precess each amount of phase shifts which corresponds by this, and the dip vector of the power of the error signal ek outputted from the subtractor 22 to each amount of phase shifts is calculated. Power of the baseband signaling yk outputted from A/D converter 9 based on the dip vector of the power of the calculated error signal ek is made into max. So that the error signal ek concerned may serve as min based on the error signal ek outputted from a subtractor 22 The amplification degree gk of each phase shift control voltage vk and i corresponding to each amount of phase shifts for turning the main beam of an array antenna 100 in the predetermined direction and the adjustable amplifier 21 is calculated. While outputting each calculated phase shift control voltage vk and i to each variable phase-shifter 3-1 thru/or 3-N through the perturbation addition circuit 30, the calculated amplification degree gk is outputted to the adjustable amplifier 21.

[0026] The perturbation addition circuit 30 is equipped with the perturbation addition voltage generator 31 which generates perturbation addition electrical-potential-difference deltav, the switch 34-1 of N individual thru/or 34-N, and the adder 33-1 thru/or 33-N of N individual, and is constituted. Here, perturbation addition electrical-potential-difference deltav generated by the perturbation addition voltage generator 31 is inputted into each contact b of a switch 34-1 thru/or 34-N, and each contact a of a switch 34-1 thru/or 34-N is grounded, respectively. Although a switch of these switches 34-1 thru/or 34-N is controlled by the switch controller 32 which operates by control of the beam control section 21 and each switch 34-1 thru/or 34-N are usually connected to Contact a side here The switching controller 32 for example, when having received the training signal it is shown in drawing 3 -- as -- time amount T / 2 of the one half of one symbol -- setting -- the sample signal (deltav=0) of the 1st non-precessing term in the sample signal of +one M=N of an M sequence signal -- then So that the sequential output of the sample signal (perturbation addition electrical-potential-difference deltav was added) of the perturbation term of two or moreN (= M-1) individual corresponding to each phase shifter 3-1 thru/or 3-N may be carried out By switching only the switch 34-1 of N individual thru/or one switch in 34-N to Contact b side one by one, it adds and adds by one of an adder 33-1 thru/or 33-N to the phase shift control voltage vk and n (n= 1, 2, --, N) outputted from the beam control section 21. The phase shift control voltage outputted from the perturbation addition circuit 30 is outputted to a phase shifter 3-1 thru/or 3-N, respectively as phase shift control voltage vk and n (n= 1, 2, --, N).

[0027] In addition, although it differs in the phase shift control voltage vk and n outputted from the beam control circuit 20, and the phase shift control voltage vk and n outputted from the perturbation addition circuit 30 when having received the training signal, and adding perturbation addition electrical-potential-difference deltav, the same notation is attached on [of explanation] expedient.

[0028] Subsequently, the principle and technical problem of the M-CMA method used with this operation gestalt are explained. In drawing 1 which shows the configuration of the adaptive array which united beam shape ** and digital signal processing by microwave signal processing, after weighting of the input signal received by the antenna element 1-1 thru/or 1-N of an array antenna 100 arranged at intervals of d in space is carried out through LNA 2-1 thru/or 2-N by the variable phase-shifter 3-1 thru/or 3-N which consists of MMIC(s) etc., it is added with the synthetic vessel 4, and it turns into an output signal of a beam formation machine. if the signal received with the i-th feed component in time of day k is set to uk and i -- the output signal sk of a beam formation machine -- an equivalence low-pass model (for example, refer to the conventional technical reference 2 ""the present-day communication line theory" besides S . Stein, Morikita Shuppan, and 1970".) -- using -- a degree type -- it is expressed like.
[0029]
[Equation 1]

$$
\begin{aligned}
s_k &= s_k(v_{k,1} \quad v_{k,2} \quad \cdots v_{k,1}) \\
&= \sum_{i=1}^{N} \exp(-j\theta(v_{k,i}))u_{k,i}
\end{aligned}
$$

[0030] In one above, vk and i are control voltage impressed to variable-phase-shifter 3-i connected to i-th antenna element 1-i, theta (-) is a phase shift characteristic function to the control voltage of variable-phase-shifter 3-i, N shows the number of antenna elements and j shows the imaginary unit. The output signal of this beam formation machine is changed into a baseband band by the down converter 5, and A/D conversion is carried out with A/D converter 9. Although the output signals sk of signal sk' by which frequency conversion was carried out, and a beam formation machine completely differ here, supposing frequency conversion and filtering are performed ideally, the difference among both is only the existence of exp (j2pft). However, f is carrier frequency, i expresses an imaginary unit and t expresses time of day. With this operation gestalt, in order to verify the upper bound of the property on the theory of a beam formation machine, the imperfection of RF band etc. is not taken into consideration. In this case, since the existence of exp (j2pft) is not an essential problem, it explains with this operation gestalt by identifying the output signal sk of signal sk' by which frequency conversion was carried out, and a beam formation machine in the same category.
[0031] The input signal by which A/D conversion was carried out is amplified by the adjustable amplifier 22-0 thru/or 22- (M-1) which is the AGC amplifier of a baseband band. The signal yk after magnification and the error with the request level sigma are defined like a degree type as an error signal ek.
[0032]
[Equation 2] Ek=sigma p-gkp|sk|p=sigma p-|yk|p, however [Equation 3] yk=gksk [0033] Here, gk is the gain of the adjustable amplifier 22-0 in time of day k thru/or 22- (M-1). Moreover, |-| in two above means taking the absolute value of complex. On the other hand, it is a multiplier in the M-CMA method, and p takes the one or more natural numbers, and is p= 2 with this operation gestalt. The gain gk of this adjustable amplifier is optimized by the following valuation basis.
[0034]
[Equation 4] J=E[|ek|q] ->min [0035] In four above, J is a cost function, E [-] is a function which takes an ensemble average, and q means the multiplier of the M-CMA method with p. Therefore, several 4 expresses the valuation basis which minimizes the cost function J. If this solution is calculated based on the well-known principle of SGD (Stochastic Gradient Decent), an optimum value will be calculated by repeating the following formulas about the gain gk of adjustable amplifier.
[0036]
[Equation 5]

$$
\begin{aligned}
& g_k \\
& = g_{k-1} - \mu \frac{\partial J}{\partial g_k} \\
& = g_{k-1} + \mu \,|\, e_k \,|^{q-2} \, e_k \,|\, y_k \,|^{p-1} |\, s_k \,|
\end{aligned}
$$

[0037] m with five above is a multiplier called a step size parameter. Furthermore, if optimization is attained to the control voltage of a beam formation machine with one above based on a valuation basis with four above, an optimum value can be found by repeating a degree type from the principle of SGD.
[0038]
[Equation 6]

$$
\begin{aligned}
& v_{k,i} \\
& = v_{k-1,i} - \mu \frac{\partial J}{\partial v_{k,i}} \\
& = v_{k-1,i} + \mu \,|\, e_k \,|^{q-2} \, e_k \,|\, y_k \,|^{p-1} \, \Delta_i \,|\, y_k \,|
\end{aligned}
$$

[0039] Here, deltai|-| expresses the fine multiplier to the control voltage of variable-phase-shifter 3-i connected to i-th antenna element 1-i, and asks for it in approximation as follows.
[0040]
[Equation 7]

$$
\begin{aligned}
& \Delta_i \,|\, y_k \,| \\
& = g_k \Delta_i \,|\, s_k(v_{k,1} \quad v_{k,2} \quad \cdots \quad v_{k,N}) \,| \\
& = g_k \{ |\, s_k(v_{k,1} \quad \cdots \quad v_{k,i} + \Delta v \quad \cdots \quad v_{k,1}) \,| - |\, s_k(v_{k,1} \quad \cdots \quad v_{k,j} \quad \cdots \quad v_{k,1}) \,| \}
\end{aligned}
$$

[0041] By using six above, it can oppress to the amplitude deflection defined by several 2 not only like the gain gk of adjustable amplifier but like the usual CMA method. However, in quest of the optimum value of control voltage, the "perturbation term" and "a non-precessing term" of this time of day are needed from six above and several 7. While this applies a perturbation, as compared with a symbol rate, A/D conversion of it is carried out to a high speed, and it can be solved by using a ******** signal. That is, since it could consider that it was almost the same since the adjacent signal had high signal correlation, and the one of the two has received the perturbation, the above-mentioned requirements can be satisfied. However, in order to raise precision, it is necessary to carry out a sample considerably at high speed, and implementation of hardware will become difficult if it takes into consideration that a bit rate will accelerate from now on. So, with this operation gestalt, this sampling rate could be reduced, in order to acquire highly precise "non-precessing term" and a "perturbation term", the time-sharing filter bank circuit 10 is used, and subsequently this is explained in full detail.
[0042] Although frequency conversion of the output signal of the beam formation machine shown by one above is carried out with a down converter 5 and it is changed into a digital signal by A/D converter 9, the sampling rate at that time is performed by M times of an information rate, a digital filter removes an undesired signal, and the system which acquires a recovery signal by performing decimation is used. When it constitutes this digital filter from an FIR (Finite Impulse Response) filter, generally the poliphase expression of that transfer function T (z-1/M) can be carried out as follows.
[0043]
[Equation 8]

$$
\begin{aligned}
&T(z^{-1/M}) \\
&= \sum_{i=-ML}^{ML-1} h_{i/M} Z^{-i/M} \\
&= \sum_{i_2=0}^{M-1} \sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} Z^{-i_1-i_2/M} \\
&= \sum_{i_2=0}^{M-1} z^{-i_2/M} \sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} Z^{-i_1} \\
&= \sum_{i_2=0}^{M-1} T_{i_2}(z^{-1})
\end{aligned}
$$

[0044] However, M-1 is Tl (z-1), l= 0, --, a filter bank that constitutes each poliphase filter, and is defined like a degree type.
[0045]
[Equation 9]

$$T_l(z^{-1}) = z^{-l/M} \sum_{i=-L}^{L-1} h_{i+l/M} Z^{-i}$$

[0046] With [the working speed of each filter in a bank] a Nyquist rate [more than], the input signal of each filter is not concerned with a sampling rate, but holds fixed spectrum information. At this time, if there is no noise, the same signal will be outputted from all filter banks. However, it is necessary to satisfy the following conditions.
[0047]
[Equation 10]
Tl(z-1) =Tm(z-1);l, m= 0, --, M-1 [0048] Here, it is shown that the same signal is acquired by the filter bank concerned. When an input signal is made into uk- (i+l/M), the output signal of the poliphase filter defined by ten above is expressed like a degree type.
[0049]
[Equation 11]

$$\psi_{k,l} = \sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)}$$

[0050] When DFT (Digital Furrier Transform) of this signal is carried out, it is expressed like a degree type.
[0051]
[Equation 12]

$$
\begin{aligned}
&F(\psi_{k,l}) \\
&= \sum_{i=0}^{N-1} \sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)} \exp(-j2\pi \frac{kn}{N}) \\
&= \sum_{i=-L}^{L-1} h_{i+l/M} \exp(-j2\pi \frac{(i+l/M)n}{N}) \sum_{k=0}^{N-1} u_{k-(i+l/M)} \exp(-j2\pi \frac{(k-(i+l/M))n}{N}) \\
&= F(h_i)F(u_k)
\end{aligned}
$$

[0052] However, F (-) expresses the signal after DFT of -. That is, a signal with the same frequency spectrum is acquired from all poliphase filters. Therefore, if IDFT (Inverse DFT) of this output is carried out, there will also be no misgiving and the same time series will be acquired.
[0053] Subsequently, in order to carry out matrix representation of the transfer function of the filter bank of a poliphase expression, delay matrix F (l) which a degree type defines is introduced.

[0054]

[Equation 13] phi(l) **diag [z-l z-l-1/M -- z-l-(M-1)/M]
l=-L, --, L-1 [0055] Here, ** means what "is defined" and diag (-) means the diagonal matrix which uses the vector in a parenthesis as a diagonal element. By using this delay matrix, the transfer function of a filter bank can carry out vectorial representation like a degree type.
[0056]
[Equation 14]
phi -- ** -- [-- T -- zero -- (-- z --) -- -- T -- one -- (-- z --) -- -- -- TM - one -- (-- z --) --] -- T -- = -- [-- phi (-L) -- -- phi (-L+1) -- -- -- phi (L-1) --] -- H -- [-- 0057 --] However, H=[h-L and h-L+1/M, --, hL+(M-1)/M] T expresses the impulse response of the filter before being poliphase-ized. On the other hand, in the beam formation machine expressed with several 1, when applying the sequential perturbation from the 1st antenna element 1-1, the output signal can carry out a formula expression as follows.
[0058]
[Equation 15]

$$
\begin{aligned}
& S_k \\
& = diag[s_k \quad s_{k+1/M} \quad \cdots \quad s_{k+(M-1)/M}]^T \\
& = [W_{k,1} \quad W_{k,2} \quad \cdots \quad W_{k,N}] \begin{bmatrix} U_{k,1} \\ U_{k,2} \\ \vdots \\ U_{k,N} \end{bmatrix}
\end{aligned}
$$

[0059] Uk, i and Wk in 15 above, and i are the weighting-factor matrices over the i-th output signal and output signal of antenna element 1-i, respectively, and are expressed like a degree type.
[0060]
[Equation 16] Wk, j=diag [exp(-jtheta (vk, i)) exp(-jtheta (vk+1/M, i)) -- exp (-jtheta (vk+ (M-1) / M, i))]
[Equation 17] Uk, i=diag (uk and i uk-1/M, i -- uk- (M-1) / [M, i])
[0061] If the output signal of this beam formation machine is inputted into the time-sharing filter bank circuit 10 which is the poliphase filter bank expressed with 14 above, the input signal to the adjustable amplifier 22-0 thru/or 22- (M-1) will be acquired. That is, when the inverse z transform of the output signal is inputted and carried out to 14 above, the output-signal vector psik is expressed like a degree type using the matrix defined by 15 above.
[0062]
[Equation 18]

$$
\Psi_k = \begin{bmatrix} W_{k,1} \\ W_{k,2} \\ \vdots \\ W_{k,N} \end{bmatrix}^T \begin{bmatrix} U_{k+L,1} & U_{k+L-1,1} & \cdots & U_{k-(L-1),1} \\ U_{k+L,2} & U_{k+L-1,2} & \cdots & U_{k-(L-1),2} \\ \vdots & \vdots & \ddots & \vdots \\ U_{k+L,N} & U_{k+L-1,N} & \cdots & U_{k-(L-1),N} \end{bmatrix} H
$$

[0063] Here, it is [Equation 19] about vector thetak and i. It introduces with thetak and i**(Uk+L, i, --, [Uk, - (L-1), i]) H. if there is no effect of a noise and conditions with ten above are satisfied here -- above -- Vector theta -- there where all the elements of k and i become the same (it is as having mentioned above using several 11 and several 12.) -- the value -- theta -- if it sets with k and i -- vector P= [1, --, 1] -- using -- Vector theta -- k and i -- [Equation 20] It is expressed thetak and i**theta k and iP. Then, 18 above is rewritten like a degree type.
[0064]
[Equation 21]

$$\Psi_k = \sum_{i=1}^{N} \theta_{k,i} W_{k,j} P = [\cdots \quad \psi_{k,l} \quad \cdots] = [\cdots \quad \sum_{i=1}^{N} \theta_{k,j} \exp(-j\theta(v_{k+l/M,i})) \quad \cdots]^T$$

$$l = 0, \cdots M-1$$

[0065] 21 above is a weighting factor [several 22], after once changing the signal from each antenna element 1-1 thru/or 1-N into a baseband band and passing the digital filter of transfer function T (z). WkT=[exp (j-2 theta (vk, i), --, exp (-j2theta (vk+l/M, i)), --])
The signal equivalent to what came out of and carried out weighting means being outputted from the filter of eye l/M watch of the time-sharing filter bank circuit 10 which is a poliphase filter bank. Then, weighting factors Wk and i are operated like a degree type. However, it considers as M>=N +1 (with drawing 1 thru/or the operation gestalt of drawing 3 , it is considering as M=N +1.).
[0066]
[Equation 23] Here, it is i= 1, --, N and l= 0, --, M-1 at the time of vk+l/M, i=vk, and i+delta v;i!=l at the time of vk+l/M, i=vk, and i;i!=l.
[0067] That is, in M continuous input signal sequences, a perturbation is not given to the first sample signal at all, but the perturbation is applied to the control voltage of the variable phase-shifter 3-1 connected to each component from the following sample thru/or 3-N one by one. Specifically by the l-th sample signal, a perturbation is given only to the l-th control voltage of variable-phase-shifter 3-l. The 0th filter of the time-sharing filter bank circuit 10 which is a poliphase filter bank by this (in the time-sharing filter bank circuit 10 of drawing 2) Signal psik of a non-precessing term and 0 are outputted from a digital filter 13-0 and the down sampler 14-0, and it is the l-th filter (in the time-sharing filter bank circuit 10 of drawing 2). From digital filter 13-l and down sampler 14-l, signal psik of a perturbation term to l-th antenna element 1-l and l are outputted. Therefore, it turns out that the problem mentioned above is solvable by applying a poliphase filter. That is, the adaptive array adapting a poliphase filter of the M-CMA method can ask for the optimal multiplier based on the following successive renewal types of a multiplier.
[0068]
[Equation 24] yk, i=gkpsik, and i -- here -- i= -- 0, 1, --, M-1 -- [Equation 25] ek=sigma p-|yk and 0|p -- [Equation 26] vk, i=vk -1, i+mu|ek|q-2 ek|yk, 0|p-1 (|yk, i|-|yk, 0|)
here -- i= 0, --, M-1 -- [Equation 27]
gk-1=gk-1+ mu|ek|q-2 ek|yk, 0|p-1|psik, 0| [0069] Generally, although an anti-aliasing filter is applied as a poliphase filter, since it has the analog low pass filter in front of A/D converter 9 in communication system, the anti-aliasing filter is unnecessary. So, the time-sharing filter bank circuit 10 consists of these operation gestalten by, for example, poliphase-izing the root roll-off filter of a receiver in the nyquist filter system often used by the phase modulation system.
[0070] In drawing 1 , it is inputted into the time-sharing filter bank circuit 10 which is a poliphase filter, after passing through the low pass filter 8 which is an area JINGU filter before the A/D conversion by A/D converter 9. It is necessary to operate the digital filter 13-0 thru/or 13- (M-1) which is each root roll-off filter in the poliphase filter bank which is the time-sharing filter bank circuit 10 of drawing 2 more than by the twice of a Nyquist rate so that area JINGU distortion may not be given to a signal. Therefore, to form a root roll OFUTO filter into M-phase, it is necessary to carry out the sample of A/D converter 9 more than by 2M time of a Nyquist rate (with this operation gestalt, the sampling rate is set to f=2Mfc as mentioned above.). And after carrying out time sharing by the delay circuit 11-1 thru/or 11- (M-1) by which cascade connection was carried out, Decimation is carried out to M/2 by the M/2 twice as many down sampler 12-0 as this thru/or 12- (M-1). After passing through a digital filter 13-0 thru/or 13- (M-1), the recovery signal of the M sequence which is parallel and consists of M sample signals by which time-sharing processing was carried out is acquired by increasing decimation 4 times

by the 4 times as many down sampler 14-0 as this thru/or 14- (M-1). In addition, preferably, the multiple of the down sampler 12-0 thru/or 12- (M-1) and the multiple of the down sampler 14-0 thru/or 14- (M-1) are chosen so that those products may be set to 2M.

[0071] In drawing 3 which shows the example of the time-sharing filter bank circuit 10 of operation, the exaggerated sample of the inside of 1 symbol is carried out by twice (N+1), i.e., the twice of the element number N+1 of an antenna, and it distributes to N+1 filter bank. Each filter bank calculates by the twice of a symbol rate. A perturbation is given to the variable phase-shifter 3-1 thru/or 3-N synchronously connected to each antenna element 1-1 thru/or 1-N one by one within 1 / 2 symbols on the other hand. However, a perturbation is surely reset every 1/2 symbol, namely, the signal of a non-precessing term is generated. In addition, although all perturbations were performed within 1 symbol in drawing 3 , it is also possible to give the perturbation to the variable phase-shifter of one antenna element, whenever it receives the signal of one symbol, to perform one of this at a time, and to reduce operation speed by things. In this case, the perturbation of all components is ended only after receiving the symbol signal of N individual. However, if it takes into consideration that it is necessary to insert in 1/2 symbol the period which does not give a perturbation, a sampling rate can be reduced up to 4 times of a symbol rate.

[0072] As explained above, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit 10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.

[0073] <1st modification> drawing 4 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 in the control device of the array antenna of the 1st modification concerning this invention which is the modification of the 1st operation gestalt, and beam control circuit 20a, and the same thing as drawing 1 and drawing 2 attaches the same sign.

[0074] In the 1st operation gestalt, although it had M adjustable amplifiers 22-0 thru/or 22- (M-1) between the time-sharing filter bank circuit 10 and the beam control section 21, it is characterized by having replaced with this and inserting one adjustable amplifier 22 which has the control gain gk specified by the beam control section 21 between A/D converter 9 and the time-sharing filter bank circuit 10. Although the beam control section 21 needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 2 , 0) in the beam control processing by the M-CMA method here, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 4 , and 0 on the control gain gk. Moreover, for this, instead, as a dashed line shows drawing 4 , time-sharing separation may be carried out and the baseband signaling yk before gain control and 0 (baseband signaling psik of drawing 2 , 0) may be taken out from the baseband signaling uk from A/D converter 9.

[0075] According to the 1st modification constituted as mentioned above, in addition to the operation effectiveness in the 1st operation gestalt, the number of the adjustable amplifier 22 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.

[0076] <Operation gestalt of ** 2nd> drawing 5 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20t of beam control circuits in the control device of the array antenna which is the 2nd operation gestalt concerning this invention, is the block diagram showing the TRF circuit 61-1 of drawing 5 thru/or the detailed internal configuration of 61- (M-1) (it names generically and a sign 61 is attached hereafter.), and attaches the same sign about the same thing as drawing 1 thru/or drawing 4 , and drawing 10 . The control unit of the array antenna of this 2nd operation gestalt The transversal filter circuit which replaces with drawing 1 concerning the 1st operation gestalt, and the beam control circuit 20 of drawing 2 , and has the TDL (Tapped Delay Line; delay line with tap) circuit 70 (it is hereafter called a TRF

circuit.) While having 61, it is characterized by having 21t of beam control circuits equipped with 21t of beam control sections which perform beam control of an ecad using the signal-processing M-CMA method between space-time which carries out the detail after-mentioned. Other configurations are the same as that of the 1st operation gestalt, and omit detail explanation here.

[0077] In drawing 5 , baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9 and m (m= 0, 1 and 2, --, M-1) While being inputted into the adjustable amplifier 72-0 in 21t of beam control sections, and the TRF circuit 61, the delay circuit 71-1 of two or more (L-1) individuals thru/or 71- (L-1) are inputted into the delay circuit 71-1 of the 1st step of the TDL circuit 70 which comes to carry out cascade connection. Above-mentioned baseband signaling psik and m are outputted to 21t of beam control sections, and an adder 73 through the delay circuit 71-1 of two or more (L-1) stages thru/or 71- (L-1), and adjustable amplifier 72- (L-1) while they are outputted to an adder 73 through the adjustable amplifier 72-0. In the TDL circuit 70, each delay circuit 71-1 thru/or 71- (L-1) delay for it and output only the predetermined time delay tau for the signal inputted, respectively. Here, although a time delay tau is preferably set as one half of 1 symbol time amount, it may be set, for example as less than [1 symbol time amount or it].
[0078] Delay signal bpk-1 of baseband signaling psik outputted from a delay circuit 71-1 and m=bpk is outputted to an adder 73 through the adjustable amplifier 72-1 while it is outputted to 21t of beam control sections. Moreover, delay signal bpk-2 of the baseband signaling bpk outputted from a delay circuit 71-2 are outputted to an adder 73 through the adjustable amplifier 72-2 while they are outputted to 21t of beam control sections. Furthermore, delay signal bpk-3 of the baseband signaling bpk outputted from a delay circuit 71-3 are outputted to an adder 73 through the adjustable amplifier 72-3 while they are outputted to 21t of beam control sections. Still more nearly similarly, delay signal bpk-L of the baseband signaling bpk outputted from delay circuit 71- (L-2) is outputted to an adder 73 through adjustable amplifier 72- (L-2) while it is outputted to 21t of beam control sections. The adjustable amplifier (or gain control machine) 72-0 thru/or 72- (L-1) amplify and (or gain control) output the signal inputted by the amplification degree w0 set up by 21t of beam control sections thru/or wL-1, respectively, and amplification degree (or gain) takes the value of ****** here. And an adder 73 adds delay signal bpk-1 thru/or bpk-L +1 of the baseband signaling bpk inputted and its two or more (L-1) individuals, and outputs the signal of an addition result to 21t of beam control sections as output signals yk and m (m= 0, 2 [1 and 2], --, M-1). In addition, an output signal yk and 0 are outputted also to a subtractor 24. Thus, by constituting, the TRF circuit 61 equipped with the TDL circuit 70, the adjustable amplifier 72-0 thru/or 72- (L-1), and an adder 73 is constituted. That is, each adjustable amplifier 22-0 thru/or 22- (M-1) in the 1st operation gestalt consists of the 2nd operation gestalt in the TRF circuit 61 of drawing 6 .
[0079] On the other hand, the reference signal generator 23 generates the reference signal sigma which has predetermined constant value, and outputs it to a subtractor 24. A subtractor 24 subtracts an output signal yk and 0 from a reference signal sigma, and outputs the error (or deflection) signal ek to 21t of beam control sections. The error signal ek into which 21t of beam control sections is inputted, and baseband signaling bkk, It is based on the delay signal bkk-1 thru/or yk-L +1, and the TRF circuit 61-0 thru/or the baseband signaling yk and m (m= 0, 2 [1 and 2], --, M-1) after passage of 61- (M-1). Only a predetermined shift amount is made to precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i (i= 1, 2, --, N) of 3-N by controlling the perturbation addition circuit 30 using the signal-processing M-CMA method between space-time. Make only a predetermined response shift amount precess each amount of phase shifts which corresponds by this, and the dip vector of the power of the error signal ek outputted from the subtractor 24 to each amount of phase shifts is calculated. So that the error signal ek concerned may serve as min based on the error signal ek outputted from a subtractor 24 based on the dip vector of the power of the calculated error signal ek Each phase shift control voltage vk and i corresponding to each amount of phase shifts for turning the main beam of an array antenna 100 in the predetermined direction and each adjustable amplifier 72-0 the amplification degree w0 of 72- (L-1) thru/or wL-1 are calculated. It is outputted and

set as each variable phase-shifter 3-1 thru/or 3-N and each adjustable amplifier 72-0 thru/or 72- (L-1), respectively.

[0080] In the control device of the array antenna concerning the 2nd operation gestalt constituted as mentioned above, adaptation beam control of the 20t of the beam control circuits can be accurately carried out so that an error signal ek may serve as min, the main beam of an array antenna 100 may be turned in the direction of the wave of choice and null may be turned in the direction of an interference wave. Moreover, in-phase synthesis of the delay wave of the wave of choice produced in a multi-pass transmission line can be incorporated and carried out using the TRF circuit 61, and the signal-to-noise power ratio (S/N) in the wave of choice can be improved. Moreover, although a low noise amplifier 2-1 thru/or 2-N and a variable phase-shifter 3-1 thru/or 3-N need N individual corresponding to the element number N of an antenna element 1-1 thru/or 1-N with the 2nd operation gestalt, the number of each circuitry elements is one sufficient in the circuit after the synthetic vessel 4. Therefore, as compared with the conventional example shown in drawing 10 , as compared with the conventional example, a hardware configuration is easy, and since there are few circuitry elements, there is little power consumption.

[0081] Subsequently, adaptation beam processing in which it uses with the 2nd operation gestalt is explained below. In the configuration of the adaptive array antenna concerning the 2nd operation gestalt, baseband signaling yk=yk (vk, 1, --, vk, N) can be expressed like above several 1 using a well-known equivalence low-pass model. This baseband signaling yk is inputted into the TRF circuit 61 which has the TDL circuit 70. In the TRF circuit 61, after weighting of the signal outputted from each tap of the TDL circuit 70 is carried out by the adjustable amplifier 72-0 thru/or 72- (L-1) with the amplification degree wk (i) which is a tap multiplier, respectively, it is added with an adder 73 and outputs the output signals yk and m (= it sets with zk.) shown below.

[0082]
[Equation 28]

$$z_k(v_{k,1},\ldots v_{k,N}) = \sum_{i=0}^{L-1} w_k^*(i)\; bp_{k-i}(v_{k,1},\cdots,\; v_{k,N})$$

[0083] Here, in order to perform blind control of a beam and null, minimization of the amplitude deflection of the output signal zk of the TRF circuit 61 is attained like the well-known CMA method. That is, it is [Equation 29] when the error of an output signal yk, and a 0=zk and a reference signal sigma is defined like a degree type. It becomes a requirement to satisfy the formula below ek=sigma p-|zk(vk, 1, --, vk, N) |p. However, sigma is the level of a reference signal and shows desired amplitude level.

[0084]
[Equation 30]

$$E\left[\frac{\partial e^q}{\partial v_{k,i}}\right] = 0 \qquad (i = 1, \cdots,\; N)$$

[Equation 31]

$$E\left[\frac{\partial e^q}{\partial v_{k,i}^*}\right] = 0 \qquad (i = 0, \cdots,\; L-1)$$

[0085] Here, p and q show the dimension of presumption of the CMA method, and in practice, the time of p=q=2 is called the CMA method and they are called Goddard's algorithm except it. By the CMA method, it cannot ask for several 30 partial differential by one above and several 28. Then, in this operation gestalt, make a variable phase-shifter 3-1 thru/or the control voltage vk of 3-N, 1, --, vk and N precess, each amount of phase shifts is made by this to precess like M-CMA concerning the 1st operation gestalt, and it asks. Moreover, it can ask for 31 above like the usual CMA method. Here, a multiplier update process is performed for an output signal zk as follows as zk=zk (vk (1), --, vk (N)).

[0086] The algorithm which looks for the solution with which 29 above is made into an error function and it is satisfied of 30 above and several 31 can be expressed like a degree type, if the principle of the well-known steepest descent method is applied.
[0087]
[Equation 32]
$$v_k = v_{k-1} - \mu \frac{\partial e_k^q}{\partial v_{k,i}} \fallingdotseq v_{k-1} + \mu\ e_k^{q-1} | z_k |^{p-2} \frac{\partial | z_k |}{\partial v_{k,i}}$$

[Equation 33]
$$w_k = w_{k-1} - \mu \frac{\partial e_k^q}{\partial w_k(i)} = w_{k-1} + \mu\ e_k^{q-1} | z_k |^{p-2} \frac{\partial | z_k |}{\partial w_k^*(i)}$$

[0088] 32 above and several 33 are the formulas of the algorithm for satisfying 30 above and several 31, respectively. The partial-differential term in 32 above can be acquired using the approximation of a partial differential with 26 above. On the other hand, the partial-differential term in 31 above can be directly searched for by carrying out the partial differential of the both sides with 28 above. Therefore, 32 above and several 33 become a degree type, and perform convergence processing using the renewal type of a multiplier of a degree type.
[0089]
[Equation 34] vk, i=vk -1, i+mu vekq-1|zk|p-2deltai|zk| (i= 1, --N),
[Equation 35] wk(i) =wk-1(i)+muwekq-1|zk|p-2 zk*yk (i= 0, --L-1),
[0090] However, [Equation 36] It is deltai|zk|=deltai|zk(vk, 1, --, vk and i, --, vk, N) |=|zk(vk1, --, vk, i+deltav, --, vk, N) |-|zk(vk, 1, --, vk and i, --, vk, N) |.
[0091] In 46 above, deltav is a very small term for a perturbation, and 34 above, and muv and muw in several 35 are the step sizes of the tap multiplier which are the control voltage of a phase shifter 3-1 thru/or 3-N, and the amplification degree of the adjustable amplifier 72-0 thru/or 72- (L-1), respectively. In order to carry out right convergence of the algorithm of the signal-processing M-CMA method between space-time concerning this operation gestalt, two kinds of this step size needs to satisfy the following conditions.
[0092]
[Equation 37] muw=muvdeltav -- here, the unit of deltav is a radian.
[0093] As explained above, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit 10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.
[0094] <2nd modification> drawing 7 is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 2nd modification concerning this invention which is the modification of the 2nd operation gestalt, and the configuration of beam control circuit 20ta, and the same thing as drawing 5 and drawing 6 attaches the same sign.
[0095] In the 2nd operation gestalt, although it had M TRF circuits 61-0 thru/or 61- (M-1) between the time-sharing filter bank circuit 10 and 21t of beam control sections, it is characterized by having replaced with this and inserting one TRF circuit 61 which has the weighting factor specified by 21t of beam control sections between A/D converter 9 and the time-sharing filter bank circuit 10. Although 21t of beam control sections needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 5 , 0) here in the beam control processing by the signal-processing M-CMA method between space-time, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 7 , and 0 by the weighting multiplier. Moreover, for this, instead, as a dashed line shows drawing 7 , time-sharing separation may be carried out and the baseband

signaling yk before gain control and 0 (baseband signaling psik of drawing 7 , 0) may be taken out from the baseband signaling uk from A/D converter 9.
[0096] According to the 2nd modification constituted as mentioned above, in addition to the operation effectiveness in the 2nd operation gestalt, the number of the TRF circuit 61 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.
[0097] <Operation gestalt of ** 3rd> drawing 8 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20m of beam control circuits in the control device of the array antenna which is the 3rd operation gestalt concerning this invention, and attaches the same sign about the same thing as drawing 1 thru/or drawing 7 , and drawing 10 . The control device of the array antenna of this operation gestalt is characterized by having 20m of beam control circuits which have 21m of beam control sections.
[0098] 20m of beam control circuits is based on baseband signaling psik which is an output signal from A/D converter 9, and m (m= 0, 1 and 2, --, M-1) through a demodulator 7 and the time-sharing filter bank circuit 10. The minimum an average of 2 multiplication which carries out the detail after-mentioned and which deformed (it is hereafter called the M-LMS method.) Use and only a predetermined shift amount is made to precess each amount of phase shifts of a variable phase-shifter 3-1 thru/or 3-N by controlling the perturbation addition circuit 30, respectively. The variation delta yk and m which calculated the variation delta yk and m before and behind the perturbation of the baseband signaling yk and m outputted from the adjustable amplifier 82-0 thru/or 82- (M-1) to each amount of phase shifts, and was calculated, Baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and 0, The baseband signaling yk and m outputted from the adjustable amplifier 82, baseband signaling psik and the baseband signaling yk by which gain control was carried out with the adjustable amplifier 82 in 0, 0 and the sign distinction value dk (it is the output of the sign distinction machine 83.) of that Based on the error signal ek of a between, so that the root mean square of the error signal ek concerned may serve as min It is characterized by calculating each above-mentioned amount of phase shifts and the above-mentioned gain gk for turning the main beam of the above-mentioned array antenna in the predetermined direction, and outputting to each variable phase-shifter 3-1 thru/or 3-N and the adjustable amplifier 82-0 thru/or 82- (M-1), respectively.
[0099] 20m of beam control circuits is equipped with 21m of beam control sections, the adjustable amplifier 82-0 thru/or 82- (M-1), the sign distinction machine 83, and a subtractor 84, and they are constituted. baseband signaling psi into which each adjustable amplifier 82-0 thru/or 82- (M-1) are inputted here -- the baseband signaling yk and m by which amplified k and m on the control gain gk shown by the beam control section 81, and gain control was carried out -- 21m of beam control sections -- outputting -- moreover -- among those, baseband signaling yk and 0 are outputted to the sign distinction machine 83, a subtractor 84, and 21m of beam control sections. Subsequently, the sign distinction machine 83 calculates the sign distinction value dk of the baseband signaling yk inputted, and outputs it to a subtractor 84 so that it may mention later. Furthermore, a subtractor 84 subtracts baseband signaling yk and 0 from the sign distinction value dk, and outputs the error signal ek of a subtraction result to the beam control section 81. And the beam control section 81 calculates the adjustable control voltage vk and i (i= 1, 2, --, N), and outputs it to a variable phase-shifter 3-1 thru/or 3-N, respectively while it calculates the control gain gk using the M-LMS method based on an error signal ek in baseband signaling psik inputted, 0 and yk and m, and a list and outputs it to the adjustable amplifier 82.
[0100] In the predetermined training period before performing data transmission in this beam control circuit 80 only based on baseband signaling psik after A/D conversion, using the M-LMS method By making only a predetermined shift amount precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i to 3-N by controlling the perturbation addition circuit 30 The variation delta yk and m which calculated the variation delta yk and m before and behind the perturbation of the baseband signaling yk and m outputted from the adjustable amplifier 82 to each amount of phase shifts, and was calculated, Baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and 0, The baseband signaling yk and m outputted from the adjustable amplifier 82-0 thru/or 82- (M-1),

baseband signaling yk, 0 sign distinction values dk (it is the output of the sign distinction machine 83.) Based on baseband signaling yk and the error signal ek between 0, so that the root mean square of the error signal ek concerned may serve as min Each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction are calculated, and it outputs to each variable phase-shifter 3-1 thru/or 3-N and the adjustable amplifier 82-0 thru/or 82- (M-1), respectively.

[0101] In the control device of the array antenna constituted as mentioned above, 20m of beam control circuits forms the main beam of an array antenna 100 in the predetermined direction accommodative so that the root mean square of the error signal ek generated with the subtractor 84 of 20m of beam control circuits may serve as min. Although a low noise amplifier 2-1 thru/or 2-N and a variable phase-shifter 3-1 thru/or 3-N need N individual corresponding to the element number N of an antenna element 1-1 thru/or 1-N in the control unit of the constituted array antenna, the number of each circuitry elements is one sufficient in the circuit after the synthetic vessel 4. Therefore, as compared with the conventional example shown in drawing 10 , a hardware configuration is easy, and since there are few circuitry elements, there is little power consumption.
[0102] Subsequently, the control algorithm in 20m of beam control circuits is explained. First, the baseband signaling yk and m which is outputted from the adjustable amplifier 82-0 thru/or 82- (M-1) and by which gain control was carried out is expressed with a degree type.
[0103]
[Equation 38] yk, m=gkpsik, m [0104] Here, psik and m are the baseband signaling which was outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and was expressed with complex, gk is the gain of the adjustable amplifier 82-0 thru/or 82- (M-1) expressed with the real number, and yk and m show each output signal of the adjustable amplifier 82-0 thru/or 82- (M-1) expressed with complex. At this time, an error signal ek is defined like a degree type.
[0105]
[Equation 39] ek=dk-yk, 0 [0106] Here, dk is an output signal which shows the sign distinction value from the sign distinction machine 83, and is calculated like a degree type.
[0107]
[Equation 40] dk=sgn[Re(yk)]+j-sgn [Im (yk)]
[0108] Here, Re [-] is a function which shows the real number of an argument, and Im [-] is a function which shows the imaginary of an argument. Moreover, sgn [x] is a sign discriminant function and is defined as follows.
[0109]
[Equation 41] sgn[x]
= At the time of 1; x>=0 = it is [0110] at the time of -1; x<0. At this time, the gain of each adjustable amplifier 82-0 thru/or 82- (M-1) is updated like a degree type.
[0111]
[Equation 42] gk=gk-1+muRe [psik, 0ek*]
[0112] Here, mu is called a step size parameter and is the suitable constant of 0< mu<1. Moreover, * shows a complex conjugate. On the other hand, the control voltage of variable-phase machine 3-i is updated like a degree type.
[0113]
[Equation 43] vk, i=vk -1, i+mu Re (ek*delta yk and i)
[0114] At this time, Variation delta yk and i is calculated like a degree type.
[0115]
[Equation 44] deltayk, i=yk, 0 (1 vk- 1, 1, --, vk- 1, i+deltav, --, vk- N)
- yk, 0 (1 vk- 1, 1, --, vk- 1, i, --, vk- N)
[0116] phase shift control voltage vk- of the time of day k-1 in case the 2nd term of the several 44 right-hand side does not add a perturbation electrical potential difference -- 1, 1, --, vk-1, i, -- and the baseband signaling yk with which gain control of [when impressing vk-1 and N to each variable phase-shifter 3-1 thru/or 3-N] was carried out are shown. moreover, the 1st

term of the several 44 right-hand side -- phase shift control voltage vk- of time of day k-1 -- 1, 1, --, v<SUB>k -1, i, --, vk-1, and N -- in addition, the baseband signaling yk with which gain control of [when applying perturbation electrical-potential-difference deltav to an excess] was carried out only to variable-phase-shifter 3-i corresponding to i-th antenna element 1-i, and 0 are shown. And delta yk(s) and i which are expressed with several 44 are the variation yk of these two signals, i.e., the baseband signaling before and behind perturbation, and the variation of 0.

[0117] Therefore, based on the baseband signaling yk before and behind the calculated perturbation, the variation delta yk and i of 0, and an error signal ek, the phase shift control voltage vk and i is calculated and set up so that clearly from several 43. And the adjustable amplifier 82-0 thru/or the gain gk of 82- (M-1) are determined and set up so that from several 42, and the root mean square of an error signal ek may serve as min. Thus, by carrying out beam control, by using the pilot signal used by the preamble especially used by TDMA etc., CDMA, etc. as a request signal, the main beam of the array antenna concerned can be turned in the predetermined direction, and a subcarrier pair interference wave power ratio (CIR) turns a beam in the direction of a request wave, also when level is lower than an interference wave, and minus, i.e., a request signal, can form null in the direction of an interference wave.

[0118] In this operation gestalt, digital signal processing performs amplitude control to the output baseband signaling yk and m which minded the time-sharing filter bank circuit 10 from A/D converter 9, and by variable-phase-shifter control of a microwave band (RF band), since a phase-shifter input signal cannot be observed, the amount of updating of a multiplier is calculated by the perturbation. Moreover, by amplitude control, since the output baseband signaling yk and m is acquired as a digital signal, an amplitude presumption algorithm is obtained in several 42 format. Moreover, since the invented algorithm uses the same norm as the well-known LMS method of minimization of the mean square of an error signal ek, it is calling the invented algorithm the "M-LMS method."

[0119] the adaptive array realized in the DBF circuit since beam control was carried out using the M-LMS method according to this operation gestalt as explained above -- the same -- a beam and null -- it can control and is -- in addition, since RF band can perform beam shape **, there is an advantage that the cutback of circuit magnitude or cost is attained as compared with the conventional example. Therefore, a configuration is easy and there is little power consumption. Moreover, by using the pilot signal used by the preamble used by TDMA etc., CDMA, etc. as a request signal, a subcarrier pair interference wave power ratio (CIR) turns a beam in the direction of a request wave, also when level is lower than an interference wave, and minus, i.e., a request signal, can form null in the direction of an interference wave. Therefore, even if it is an inferior environment, adaptation actuation can be carried out to stability.

[0120] Moreover, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit 10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.

[0121] <3rd modification> drawing 9 is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 3rd modification concerning this invention which is the modification of the 3rd operation gestalt, and the configuration of beam control circuit 20ma, and the same thing as drawing 8 attaches the same sign.

[0122] In the 3rd operation gestalt, although it had the adjustable amplifier 82-0 thru/or 82- (M-1) between the time-sharing filter bank circuit 10 and 21m of beam control sections, it is characterized by having replaced with this and inserting one adjustable amplifier 82 which has the weighting factor specified by 21m of beam control sections between A/D converter 9 and the time-sharing filter bank circuit 10. Although 21m of beam control sections needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 8 , 0) in the

beam control processing by the M-LMS method here, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 9 , and 0 on the control gain gk. Moreover, for this, instead, as a dashed line shows drawing 9 , time-sharing separation may be carried out and the baseband signaling yk before gain control and 0 (baseband signaling psik of drawing 9 , 0) may be taken out from the baseband signaling uk from A/D converter 9.

[0123] According to the 3rd modification constituted as mentioned above, in addition to the operation effectiveness in the 3rd operation gestalt, the number of the adjustable amplifier 82 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.

[0124] In the operation gestalt more than modification > besides <, although digital signal processing is performed in the subsequent circuit after carrying out A/D conversion of the baseband signaling using A/D converter 9, A/D converter 9 may not be inserted but signal processing may be analogically performed in a subsequent circuit.

[0125] In the above operation gestalt, although the perturbation addition circuit 30 consists of circuits where each beam control circuits 20, 20a, and 20t, 20ta, 20m, and 20ma are another, it may unify and constitute the function of the perturbation addition circuit 30 from software or hardware circuitry in each beam control circuits 20, 20a, and 20t, 20ta, 20m, and 20ma.

[0126]

[Example] Furthermore, since this invention persons experimented in the interference oppression property of the adaptive array adapting a poliphase filter of the M-CMA method concerning the 1st operation gestalt by computer simulation, they explain the experiment approach and experimental result in full detail below.

[0127] It was premised on the transmitter-receiver configuration which applied differentially coherent detection to the wave detector, using a QPSK modulation technique as a modulation technique. Moreover, the transmission line applied the AWGN (Additive White Gaussian Noise) channel. An antenna is a linear array antenna of half-wave length spacing, and the element number was set to 4. moreover -- if the direction of a transverse plane of a linear array antenna is made into 0 times -- the wave of choice -- the direction of -50 degrees to an interference wave -- from the direction of 30 degrees -- etc. -- the environment which carries out incidence on level was assumed. Moreover, the multiplier of the M-CMA method was set as p=q=1, and it considered as the step size mu= 0.0001. The exaggerated sample carried out by 4 times the symbol rate for reduction of processing speed. Moreover, the initial state of an array antenna forms the beam in the direction of a transverse plane.

[0128] Drawing 11 is as a result of [of the 1st operation gestalt] simulation, and is a graph which shows the directivity response pattern in the case of a four-element linear array antenna. The beam which has the about 12dB array factor of a theoretical limitation in the direction of the wave of choice is formed so that clearly from drawing 11 . It turns out that deep null can be formed in the direction of an interference wave. However, when SNR is low, the location of null is shifted a little. Control concentrates on the direction which forms a beam and this is considered for sensibility to fall to null somewhat, when SNR is low.

[0129] Drawing 12 is as a result of [of the 1st operation gestalt] simulation, and is a graph which shows the property of a bit error rate (BER) over the subcarrier/noise power ratio in the case of a four-element linear array antenna (CNR). In drawing 12 , the property of the differentially coherent detection at the time of the four-element maximum ratio composition diversity reception in conditions without interference is shown as a theoretical value. Since the adaptive array using the M-CMA method not only turns a beam to the wave of choice, but can form sharp null in the direction of an interference wave, in all CNR conditions, it turns out that the outstanding property which carries out asymptotic to a theoretical value even at 1.5dB is acquired. It is thought that this 1.5dB degradation is based on the sensibility lowering to the null mentioned above.

[0130] As explained above, the poliphase filter was used as the effective implementation approach of the M-CMA method which enables adaptation beam control in the analog beam shape molding adaptive array in which small and low-pricing are possible. In the renewal type of a

multiplier of the M-CMA method, the "perturbation term" and "a non-precessing term" of this time of day are theoretically needed. It uses that consider as the approach of acquiring this signal simply, and the time-sharing filter bank circuit 10 equipped with each filter bank which constitutes a poliphase filter outputs the completely same wave as this time of day. That is, different perturbation for every filter or a non-precessing term is outputted to each poliphase filter in the time-sharing filter bank circuit 10 by distributing the signal which does not receive a perturbation with a carrier beam signal.

[0131]

[Effect of the Invention] As explained in full detail above, according to this invention, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Field of the Invention] This invention relates to the control unit and the control approach for controlling the array antenna equipped with two or more antenna elements.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Drawing 10 is the block diagram showing the configuration of the control device of the array antenna of the conventional example. A radio signal is received in drawing 10 by the array antenna 100 by which it comes to juxtapose two or more the antenna elements 1-1 thru/or 1-N of N individual on 1 straight line at the predetermined spacing mutually. The radio signal received by each antenna element 1-1 thru/or 1-N, respectively A low noise amplifier (LNA) 2-1 thru/or 2-N, the down converter 5-1 that carries out frequency conversion to the intermediate frequency signal of a predetermined intermediate frequency, or 5-N, It is outputted to the beam control circuit 93 and a variable phase-shifter 91-1 thru/or 91-N through A/D converter 9-1 thru/or 9-N which performs the demodulator 7-1 thru/or 7-N and the analog / digital conversion which restores to an intermediate frequency signal to baseband signaling. A variable phase-shifter 91-1 thru/or 91-N output the baseband signaling inputted to the synthetic vessel 92, after carrying out the phase shift only of the amount of phase shifts in which it is directed from the beam control circuit 93, respectively. The synthetic vessel 92 is outputted to an external device while it carries out power composition of the baseband signaling of a two or more N individual inputted and outputs the baseband signaling after composition to the beam control circuit 93.
[0003] Each baseband signaling into which the beam control circuit 93 is inputted from A/D converter 9-1 thru/or 9-N here, Adaptation beam control algorithms, such as technique based on the criteria of MMSE (Minimizing Mean Square Error), such as law, are used. the baseband signaling after composition -- being based -- for example, well-known LMS (Least Mean Square) -- It outputs in order for the baseband signaling after composition to serve as max, and to calculate each amount of phase shifts of the variable phase-shifter 91-1 by which an array antenna 100 turns the main beam in the predetermined direction thru/or 91-N and to control each variable phase-shifter 91-1 thru/or 91-N.
[0004] The so-called control device of the ecad array antenna constituted as mentioned above is highly efficient antenna control equipment which can obtain the directivity response pattern which was adapted for the received electric-wave environment by combining with two or more antenna elements 1-1 thru/or 1-N, and radio set circuits the variable phase-shifter 91-1 which is a digital-signal-processing circuit thru/or 91-N, the synthetic vessel 92, and the beam control circuit 93. the configuration which used the digital beam formation circuit (DBF) in the conventional example of drawing 10 -- it is -- forming the main beam of an array antenna in the direction of a request incoming wave **** -- the direction of an interference wave -- null -- it has the function to form a point and to remove this.
[0005] However, since A/D converter 9-1 thru/or 9-N needed to be used for the receiving-circuit (low noise amplifier 2-1 thru/or 2-N, down converter 5-1 or 5-N and demodulator 7-1 thru/or 7-N) list for every antenna element 1-1 thru/or 1-N, there was a trouble that hardware magnitude and power consumption became large. Especially, when it is a high interest profit antenna with many element numbers of an antenna element, especially this problem will become serious. Furthermore, since it receives for every antenna element, there is also a fault that actuation becomes difficult under the environment to which signal level fell.
[0006] In order to solve this trouble, this invention persons "For example, the conventional

technical reference 1 "M-CMA besides Tano (Modified Constant Modulus Algorithm), - In digital-signal-processing algorithm-" for adaptation beam shape ** by microwave signal processing, the Institute of Electronics, Information and Communication Engineers research report and A-P 99-62, and pp.15 1999 [-22 or]" M-CMA (ModifiedConstant Modulus Algorithm) is proposed as adaptation algorithm suitable for the adaptive array which performs beam shape ** with this microwave band, and performs digital-signal-processing control. By this M-CMA method, it is premised on constituting a beam formation machine from a variable phase-shifter and an adder for simplification of a hardware configuration. in order that the M-CMA method may make a valuation basis minimization of the average square error of amplitude deflection like the CMA method -- the CMA method -- the same -- beam steering and null -- the concurrency control of a steering is possible. Needless to say, since it is positioned in a blind algorithm, before the M-CMA method establishes frame synchronization, and a frequency and phase simulation, beam formation is possible for it. Therefore, beam shape ** is performed before various synchronous establishment, and from a beam formation machine, since the high signal of SINR (Signal to Interference and NoiseRatio) is supplied after IF stage, various synchronizations also have the advantage of being easily establishable, under the inferior SINR environment. The M-CMA method presumes the dip vector in the error flat surface over the control voltage of each variable phase-shifter using a perturbation theoretically.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained in full detail above, according to this invention, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, by the M-CMA method, the output signal (perturbation term) of the beam formation machine when giving a perturbation to the input signal of the same time of day and the output signal (non-precessing term) of the beam formation machine which is not given are needed in an updating type. There is an approach using a high-speed sampling as a means to ask for this in approximation. This samples the output signal of a beam formation machine at a high speed to a symbol rate, and uses the signal with which this output adjoined each other as "a non-precessing term" and a "perturbation term" at the same time it applies a perturbation. If the effect of a noise is disregarded, correlation of the signal with which the output signal of the beam formation machine by which the high-speed sample was carried out adjoined each other will be dramatically high to this principle of operation, and it will use that the difference among both is only a difference in the existence of a perturbation for it. However, there was a trouble that the A/D converter which can perform a very high-speed sampling in this case as compared with a bit rate being needed, and sampling timing adjustment were difficult, and circuitry became complicated.
[0008] The object of this invention solves the above trouble and it is in offering the control unit and the control approach of an array antenna as for which control of the main beam and control of null are made to accuracy as a beam formation direction in time [as compared with the conventional example, a configuration is easy, and].

[Translation done.]

* NOTICES *

MEANS

[Means for Solving the Problem] the control unit of the array antenna concerning this invention -- two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain control of the baseband signaling outputted from the above-mentioned recovery means, and to output it on predetermined gain, A subtraction means to generate and output the error signal between the baseband signaling outputted from the above-mentioned gain control means, and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. So that the dip vector of the power of the error signal outputted from the above-mentioned subtraction means over each amount of phase shifts may be calculated and the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control unit of the array antenna equipped with the control means which calculates the gain of each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the above-mentioned gain control means, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-sharing processing so that it may be outputted as an output signal.
[0010] In the control device of the above-mentioned array antenna, the above-mentioned gain control means is preferably characterized by being a transversal filter circuit.
[0011] Moreover, the control unit of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- two or more [to which the phase shift only of the predetermined amount of phase shifts is carried out, and it outputs N radio signals, respectively] -- with N phase shift means A synthetic means outputted from each above-mentioned phase shift means to compound two or more radio signals of N individual, and to output the radio signal after composition, A recovery means to restore to it and output the radio signal outputted from the above-mentioned synthetic means to baseband signaling, A gain control means to carry out gain control of the baseband signaling outputted

from the above-mentioned recovery means, and to output it on predetermined gain, A sign distinction means to output the sign distinction value signal which distinguishes the sign of the baseband signaling outputted from the above-mentioned gain control means, and shows a sign distinction value, A subtraction means to generate and output the error signal between the sign distinction value signal outputted from the above-mentioned sign distinction means, and the baseband signaling outputted from the above-mentioned gain control means, The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before and behind the perturbation of the baseband signaling outputted from the above-mentioned gain control means to each amount of phase shifts, and was calculated, Based on the baseband signaling outputted from the above-mentioned recovery means, the baseband signaling outputted from the above-mentioned gain control means, and the error signal outputted from the above-mentioned subtraction means, so that the root mean square of the above-mentioned error signal may serve as min It has the control means which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It is inserted and prepared between the above-mentioned recovery means and the above-mentioned gain control means or between the above-mentioned gain control means, the above-mentioned control means, and the above-mentioned subtraction means. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by having further a time-sharing processing means for two or more sample signals within the above-mentioned sequence signal in the period which it precessed to differ and to perform time-sharing processing so that it may be outputted as an output signal.

[0012] Preferably, the control unit of the above-mentioned array antenna is inserted and formed in the latter part of the above-mentioned recovery means, carries out analog-to-digital conversion to the baseband signaling outputted from the above-mentioned recovery means, and is characterized by having further a conversion means to output the digital baseband signaling after conversion.

[0013] Furthermore, the control approach of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals using two or more phase shift means with the step to which the phase shift only of the predetermined amount of phase shifts is carried out, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which generates the error signal between the baseband signaling by which gain control was carried out [above-mentioned], and the reference signal of a predetermined value, Only a predetermined shift amount is made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively. Calculate the dip vector of the power of the above-mentioned error signal over each amount of phase shifts, and so that the error signal concerned may serve as min based on the dip vector and the above-mentioned error signal of power of an error signal which were calculated In the control approach of the array antenna containing the step which calculates each amount of phase shifts for turning the main beam of the above-mentioned array antenna in the predetermined direction, and the gain of the above-mentioned step which carries out gain control, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate the above-mentioned step which carries out gain control,

the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.

[0014] In the control approach of the above-mentioned array antenna, the above-mentioned step which carries out gain control is preferably characterized by performing using a transversal filter circuit.

[0015] Furthermore, the control approach of the array antenna concerning this invention two or more -- two or more [by which N antenna elements were received by each antenna element of the array antenna which it comes to juxtapose each other at the predetermined spacing] -- N radio signals with the step to which the phase shift only of the predetermined amount of phase shifts is carried out using two or more phase shift means, respectively The step by which the phase shift was carried out [above-mentioned] and which compounds two or more radio signals of N individual, and outputs the radio signal after composition, The step which restores to the radio signal after the above-mentioned composition to baseband signaling, and the step which carries out gain control of the baseband signaling by which the recovery was carried out [above-mentioned] on predetermined gain using a gain control means, The step which outputs the sign distinction value signal which distinguishes the sign of the baseband signaling by which gain control was carried out [above-mentioned], and shows a sign distinction value, The step which generates the error signal between the above-mentioned sign distinction value signal and the baseband signaling by which gain control was carried out [above-mentioned], The variation which only the predetermined shift amount was made to precess each amount of phase shifts of two or more above-mentioned phase shift means, respectively, calculated the variation before and behind the perturbation of the baseband signaling by which gain control was carried out [above-mentioned] to each amount of phase shifts, and was calculated, Based on the baseband signaling by which the recovery was carried out [above-mentioned], the baseband signaling by which gain control was carried out [above-mentioned], and the above-mentioned error signal, so that the root mean square of the above-mentioned error signal may serve as min It has the step which calculates each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction, and is outputted to each above-mentioned phase shift means and the above-mentioned gain control means, respectively. The above-mentioned baseband signaling includes a sequence signal including two or more sample signals. It performs between the above-mentioned step which carries out a recovery, and the above-mentioned step which carries out gain control, or between the steps which generate the above-mentioned step which carries out gain control, the above-mentioned step which carries out count, and the above-mentioned error signal. At least one sample signal in the period which it does not precess based on the baseband signaling inputted, It is characterized by including further the step which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the above-mentioned sequence signal in the period which it precessed differ.

[0016] The control approach of the above-mentioned array antenna is preferably performed after the above-mentioned step which carries out a recovery, carries out analog-to-digital conversion to the baseband signaling by which the recovery was carried out [above-mentioned], and is characterized by including further the step which outputs the digital baseband signaling after conversion.

[0017]

[Embodiment of the Invention] Hereafter, the operation gestalt which starts this invention with reference to a drawing is explained.

[0018] <Operation gestalt of ** 1st> drawing 1 is the block diagram showing the configuration of the control device of the array antenna which is the 1st operation gestalt concerning this invention, and attaches the same sign about the same thing as drawing 10 . Moreover, drawing 2 is the block diagram showing the detailed internal configuration of the time-sharing filter bank circuit 10 of drawing 1 , the beam control circuit 20, and the perturbation addition circuit 30.

[0019] The control unit of the array antenna of this 1st operation gestalt The array antenna 100 (for example, it is a linear array and may be arranged in a two-dimensional configuration or a three-dimension configuration.) with which it comes to arrange two or more the antenna elements 1-1 thru/or 1-N of N individual at the predetermined spacing mutually In the adaptive control mold control unit equipped with the beam control circuit 20 for controlling a beam using the M-CMA method One signal in the period which it does not precess between A/D converter 9 and the beam control circuit 30 in the perturbation addition circuit 30 based on the baseband signaling inputted (at least one signal may be used.) It is characterized by having the time-sharing filter bank circuit 10 which performs time-sharing processing so that it may be outputted as an output signal with which two or more sample signals within the M sequence signal which is a training signal in the period which it precessed in the perturbation addition circuit 30 differ. That is, since the time-sharing filter bank circuit 10 which consisted of this operation gestalt with a poliphase expression as an approach of solving the above-mentioned problem in the beam control which used the M-CMA method is used and the perturbation term and the non-precessing term in this time of day are acquired in a strict form by this, exact beam Nur control is enabled. Here, the digital filter 13-0 in the time-sharing filter bank circuit 10 thru/or 13- (M-1) carry out the poliphase configuration of the root roll-off filter used as a band limit filter for example, by the digital phase modulation system.
[0020] Hereafter, the configuration of the control unit of the array antenna shown in drawing 1 is explained. In drawing 1 , the radio signal which the radio signal was received and was received by each antenna element 1-1 thru/or 1-N by the array antenna 100 by which it comes to arrange two or more the antenna elements 1-1 thru/or 1-N of N individual at the predetermined spacing mutually is inputted into a variable phase-shifter 3-1 thru/or 3-N through a low noise amplifier (LNA) 2-1 thru/or 2-N, respectively. Each variable phase-shifter 3-1 thru/or 3-N output the radio signal inputted to the synthetic vessel 4, after carrying out the phase shift only of each amount of phase shifts corresponding to each phase shift control voltage vk and i (i= 1, 2, --, N) outputted from the perturbation addition circuit 30, respectively. The synthetic vessel 4 outputs only the down converter 5 which carries out power composition of the radio signal of N individual inputted, and carries out frequency conversion of the radio signal after composition to the intermediate frequency signal of a predetermined intermediate frequency, and the band component of an intermediate frequency signal to a demodulator 7 through the band-pass filter (BPF) 6 which carries out band wave filtration. A demodulator 7 restores to the radio signal inputted to baseband signaling using the recovery approach corresponding to the modulation approaches by the side of a transmitter (for example, QPSK, PSK, FSK, etc.), and outputs it to A/D converter 9 through the low pass filter (LPF) 8 which takes out only desired baseband signaling. A/D converter 9 is boiled and outputted to the beam control circuit 20 through the time-sharing filter bank circuit 10 while it carries out A/D conversion of the baseband signaling of an analog inputted to digital baseband signaling and outputs the baseband signaling signal uk after conversion to an external device.
[0021] In addition, the microwave signal processor which becomes in well-known large-scale GaAsMMIC can constitute a variable phase-shifter 3-1 thru/or 3-N and the synthetic vessel 4, for example. Moreover, in this operation gestalt, baseband signaling sets the sampling rate of A/D converter 9 to fs=2Mfc for example, including an M sequence signal as a training signal. Here, M is the one or more natural numbers, and fc is a symbol clock frequency.
[0022] The delay circuit 11-1 thru/or 11- (M-1) of an individual which is mutually connected to concatenation and has the time delay of 1/(2Mfc), respectively as the time-sharing filter bank circuit 10 is shown in drawing 2 (M-1), M down samplers 12-0 thru/or 12- (M-1) which has a twice as many down sampling rate as this, respectively (M/2), M digital filters 13-0 thru/or 13- (M-1) which has the transfer function which carries out the detail after-mentioned, respectively, for example, consists of FIR filters, It has M down samplers 14-0 thru/or 14- (M-1) which has a twice as many down sampling rate as this, respectively (1/4), and is constituted. In the time-sharing filter bank circuit 10 the baseband signaling uk from A/D converter 9 While being outputted to the beam control circuit 20 through down sampler 12- (M-1), digital filter 13- (M-1), and down sampler 14- (M-1) as baseband signaling psik by which time-sharing processing was

carried out, and M-1 It is outputted to the down sampler 12-0 through delay circuit 11- (M-1) of the individual (M-1) by which cascade connection was carried out mutually thru/or 11-1. Here, the baseband signaling uk outputted from delay circuit 11- (M-1) is outputted to the beam control circuit 20 through down sampler 12- (M-2), digital filter 13- (M-2), and down sampler 14- (M-2) as baseband signaling psik by which time-sharing processing was carried out, and M-2. baseband signaling psi by which time-sharing processing of the baseband signaling uk outputted from delay circuit 11-m was hereafter carried out similarly through down sampler 12-m, digital filter 13-m, and down sampler 14-m -- it outputs to the beam control circuit 20 as k and m -- having -- here -- m=M- it is 3, --, 0.

[0023] Drawing 3 is the block diagram showing the example of the time-sharing filter bank circuit 10 of drawing 2 of operation, and shows the case of N=M -1 as an example with this operation gestalt.

[0024] With this operation gestalt, as shown in drawing 3 , divide the time amount T of one symbol into two, and it sets to time amount T / 2. M sample signals (this corresponds an M sequence signal.) The sample signal of the 1st non-precessing term in the period to include and which does not precess M sample signals in the perturbation addition circuit 30 (deltav=0), The sample signal (perturbation addition electrical-potential-difference deltav was added) of the perturbation term of two or moreN (= M-1) individual within the M sequence signal which is a training signal in the period which it precessed in the perturbation addition circuit 30 is included. And the time-sharing filter bank circuit 10 performs time-sharing processing so that it may be outputted as an output signal with which the sample signal (deltav=0) of the 1st non-precessing term differs from the sample signal (perturbation addition electrical-potential-difference deltav was added) of M-1 perturbation term among M sample signals.

[0025] In drawing 2 , baseband signaling psik after the time-sharing processing outputted from the time-sharing filter bank circuit 10 and 0 are inputted into the beam control section 21 and a subtractor 24 through the adjustable amplifier 22-0 which has the control gain gk specified by the beam control section 21 while they are directly outputted to the beam control section 21. moreover, baseband signaling [after the time-sharing processing outputted from the time-sharing filter bank circuit 10] psi -- k and m are inputted into the beam control section 21 through adjustable amplifier 22-m which has the control gain gk specified by the beam control section 21 -- having -- here -- m= -- it is 1, 2, --, M-1. Here, control gain can take a forward or negative value. On the other hand, the reference signal generator 23 generates the reference signal sigma which has predetermined constant value, and outputs it to a subtractor 24. A subtractor 24 subtracts the baseband signaling yk after gain magnification, and 0 from a reference signal sigma, and outputs the error (or deflection) signal ek to the beam control section 21. Based on the error signal ek inputted, M baseband signaling yk by which gain control was carried out, respectively, 0 or yk, M-1, and baseband signaling psik before gain control and 0, the beam control section 21 so that the detail after-mentioned may be carried out Control the switching controller 32 of the perturbation addition circuit 30, and only a predetermined shift amount is made to precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i (i= 1, 2, --, N) of 3-N using the M-CMA method. Make only a predetermined response shift amount precess each amount of phase shifts which corresponds by this, and the dip vector of the power of the error signal ek outputted from the subtractor 22 to each amount of phase shifts is calculated. Power of the baseband signaling yk outputted from A/D converter 9 based on the dip vector of the power of the calculated error signal ek is made into max. So that the error signal ek concerned may serve as min based on the error signal ek outputted from a subtractor 22 The amplification degree gk of each phase shift control voltage vk and i corresponding to each amount of phase shifts for turning the main beam of an array antenna 100 in the predetermined direction and the adjustable amplifier 21 is calculated. While outputting each calculated phase shift control voltage vk and i to each variable phase-shifter 3-1 thru/or 3-N through the perturbation addition circuit 30, the calculated amplification degree gk is outputted to the adjustable amplifier 21.

[0026] The perturbation addition circuit 30 is equipped with the perturbation addition voltage generator 31 which generates perturbation addition electrical-potential-difference deltav, the

switch 34-1 of N individual thru/or 34-N, and the adder 33-1 thru/or 33-N of N individual, and is constituted. Here, perturbation addition electrical-potential-difference deltav generated by the perturbation addition voltage generator 31 is inputted into each contact b of a switch 34-1 thru/or 34-N, and each contact a of a switch 34-1 thru/or 34-N is grounded, respectively. Although a switch of these switches 34-1 thru/or 34-N is controlled by the switch controller 32 which operates by control of the beam control section 21 and each switch 34-1 thru/or 34-N are usually connected to Contact a side here The switching controller 32 for example, when having received the training signal it is shown in drawing 3 -- as -- time amount T / 2 of the one half of one symbol -- setting -- the sample signal (deltav=0) of the 1st non-precessing term in the sample signal of +one M=N of an M sequence signal -- then So that the sequential output of the sample signal (perturbation addition electrical-potential-difference deltav was added) of the perturbation term of two or moreN (= M-1) individual corresponding to each phase shifter 3-1 thru/or 3-N may be carried out By switching only the switch 34-1 of N individual thru/or one switch in 34-N to Contact b side one by one, it adds and adds by one of an adder 33-1 thru/or 33-N to the phase shift control voltage vk and n (n= 1, 2, --, N) outputted from the beam control section 21. The phase shift control voltage outputted from the perturbation addition circuit 30 is outputted to a phase shifter 3-1 thru/or 3-N, respectively as phase shift control voltage vk and n (n= 1, 2, --, N).

[0027] In addition, although it differs in the phase shift control voltage vk and n outputted from the beam control circuit 20, and the phase shift control voltage vk and n outputted from the perturbation addition circuit 30 when having received the training signal, and adding perturbation addition electrical-potential-difference deltav, the same notation is attached on [of explanation] expedient.

[0028] Subsequently, the principle and technical problem of the M-CMA method used with this operation gestalt are explained. In drawing 1 which shows the configuration of the adaptive array which united beam shape ** and digital signal processing by microwave signal processing, after weighting of the input signal received by the antenna element 1-1 thru/or 1-N of an array antenna 100 arranged at intervals of d in space is carried out through LNA 2-1 thru/or 2-N by the variable phase-shifter 3-1 thru/or 3-N which consists of MMIC(s) etc., it is added with the synthetic vessel 4, and it turns into an output signal of a beam formation machine. if the signal received with the i-th feed component in time of day k is set to uk and i -- the output signal sk of a beam formation machine -- an equivalence low-pass model (for example, refer to the conventional technical reference 2 ""the present-day communication line theory" besides S . Stein, Morikita Shuppan, and 1970".) -- using -- a degree type -- it is expressed like.

[0029]

[Equation 1]

$$
\begin{aligned}
s_k &= s_k(v_{k,1} \quad v_{k,2} \quad \cdots v_{k,1}) \\
&= \sum_{i=1}^{N} \exp(-j\theta(v_{k,i}))u_{k,i}
\end{aligned}
$$

[0030] In one above, vk and i are control voltage impressed to variable-phase-shifter 3-i connected to i-th antenna element 1-i, theta (-) is a phase shift characteristic function to the control voltage of variable-phase-shifter 3-i, N shows the number of antenna elements and j shows the imaginary unit. The output signal of this beam formation machine is changed into a baseband band by the down converter 5, and A/D conversion is carried out with A/D converter 9. Although the output signals sk of signal sk' by which frequency conversion was carried out, and a beam formation machine completely differ here, supposing frequency conversion and filtering are performed ideally, the difference among both is only the existence of exp (j2pft). However, f is carrier frequency, i expresses an imaginary unit and t expresses time of day. With this operation gestalt, in order to verify the upper bound of the property on the theory of a beam formation machine, the imperfection of RF band etc. is not taken into consideration. In this case, since the existence of exp (j2pft) is not an essential problem, it explains with this operation

gestalt by identifying the output signal sk of signal sk' by which frequency conversion was carried out, and a beam formation machine in the same category.
[0031] The input signal by which A/D conversion was carried out is amplified by the adjustable amplifier 22-0 thru/or 22- (M-1) which is the AGC amplifier of a baseband band. The signal yk after magnification and the error with the request level sigma are defined like a degree type as an error signal ek.
[0032]
[Equation 2] Ek=sigma p-gkp|sk|p=sigma p-|yk|p, however [Equation 3] yk=gksk [0033] Here, gk is the gain of the adjustable amplifier 22-0 in time of day k thru/or 22- (M-1). Moreover, |-| in two above means taking the absolute value of complex. On the other hand, it is a multiplier in the M-CMA method, and p takes the one or more natural numbers, and is p= 2 with this operation gestalt. The gain gk of this adjustable amplifier is optimized by the following valuation basis.
[0034]
[Equation 4] J=E[|ek|q] ->min [0035] In four above, J is a cost function, E [-] is a function which takes an ensemble average, and q means the multiplier of the M-CMA method with p. Therefore, several 4 expresses the valuation basis which minimizes the cost function J. If this solution is calculated based on the well-known principle of SGD (Stochastic Gradient Decent), an optimum value will be calculated by repeating the following formulas about the gain gk of adjustable amplifier.
[0036]
[Equation 5]

$$
\begin{aligned}
g_k &= g_{k-1} - \mu \frac{\partial J}{\partial g_k} \\
&= g_{k-1} + \mu |e_k|^{q-2} e_k |y_k|^{p-1} |s_k|
\end{aligned}
$$

[0037] m with five above is a multiplier called a step size parameter. Furthermore, if optimization is attained to the control voltage of a beam formation machine with one above based on a valuation basis with four above, an optimum value can be found by repeating a degree type from the principle of SGD.
[0038]
[Equation 6]

$$
\begin{aligned}
v_{k,i} &= v_{k-1,i} - \mu \frac{\partial J}{\partial v_{k,i}} \\
&= v_{k-1,i} + \mu |e_k|^{q-2} e_k |y_k|^{p-1} \Delta_i |y_k|
\end{aligned}
$$

[0039] Here, deltai|-| expresses the fine multiplier to the control voltage of variable-phase-shifter 3-i connected to i-th antenna element 1-i, and asks for it in approximation as follows.
[0040]
[Equation 7]

$$
\begin{aligned}
\Delta_i |y_k| &= g_k \Delta_i |s_k(v_{k,1} \quad v_{k,2} \quad \cdots \quad v_{k,N})| \\
&= g_k \{ |s_k(v_{k,1} \quad \cdots \quad v_{k,i} + \Delta v \quad \cdots \quad v_{k,1})| - |s_k(v_{k,1} \quad \cdots \quad v_{k,j} \quad \cdots \quad v_{k,1})| \}
\end{aligned}
$$

[0041] By using six above, it can oppress to the amplitude deflection defined by several 2 not only like the gain gk of adjustable amplifier but like the usual CMA method. However, in quest of the optimum value of control voltage, the "perturbation term" and "a non-precessing term" of this time of day are needed from six above and several 7. While this applies a perturbation, as compared with a symbol rate, A/D conversion of it is carried out to a high speed, and it can be solved by using a ******** signal. That is, since it could consider that it was almost the same

since the adjacent signal had high signal correlation, and the one of the two has received the perturbation, the above-mentioned requirements can be satisfied. However, in order to raise precision, it is necessary to carry out a sample considerably at high speed, and implementation of hardware will become difficult if it takes into consideration that a bit rate will accelerate from now on. So, with this operation gestalt, this sampling rate could be reduced, in order to acquire highly precise "non-precessing term" and a "perturbation term", the time-sharing filter bank circuit 10 is used, and subsequently this is explained in full detail.
[0042] Although frequency conversion of the output signal of the beam formation machine shown by one above is carried out with a down converter 5 and it is changed into a digital signal by A/D converter 9, the sampling rate at that time is performed by M times of an information rate, a digital filter removes an undesired signal, and the system which acquires a recovery signal by performing decimation is used. When it constitutes this digital filter from an FIR (Finite Impulse Response) filter, generally the poliphase expression of that transfer function T (z-1/M) can be carried out as follows.
[0043]
[Equation 8]

$$
\begin{aligned}
&T(z^{-1/M})\\
&=\sum_{i=-ML}^{ML-1} h_{i/M} z^{-i/M}\\
&=\sum_{i_2=0}^{M-1}\sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} z^{-i_1-i_2/M}\\
&=\sum_{i_2=0}^{M-1} z^{-i_2/M} \sum_{i_1=-L}^{L-1} h_{i_1+i_2/M} z^{-i_1}\\
&=\sum_{i_2=0}^{M-1} T_{i_2}(z^{-1})
\end{aligned}
$$

[0044] However, M-1 is Tl (z-1), l= 0, --, a filter bank that constitutes each poliphase filter, and is defined like a degree type.
[0045]
[Equation 9]

$$
T_l(z^{-1}) = z^{-l/M} \sum_{i=-L}^{L-1} h_{i+l/M} z^{-i}
$$

[0046] With [the working speed of each filter in a bank] a Nyquist rate [more than], the input signal of each filter is not concerned with a sampling rate, but holds fixed spectrum information. At this time, if there is no noise, the same signal will be outputted from all filter banks. However, it is necessary to satisfy the following conditions.
[0047]
[Equation 10]
Tl(z-1) =Tm(z-1);l, m= 0, --, M-1 [0048] Here, it is shown that the same signal is acquired by the filter bank concerned. When an input signal is made into uk- (i+l/M), the output signal of the poliphase filter defined by ten above is expressed like a degree type.
[0049]
[Equation 11]

$$
\psi_{k,l} = \sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)}
$$

[0050] When DFT (Digital Furrier Transform) of this signal is carried out, it is expressed like a degree type.
[0051]

[Equation 12]

$$F(\psi_{k,l}) = \sum_{i=0}^{N-1}\sum_{i=-L}^{L-1} h_{i+l/M} u_{k-(i+l/M)} \exp(-j2\pi \frac{kn}{N}) = \sum_{i=-L}^{L-1} h_{i+l/M} \exp(-j2\pi \frac{(i+l/M)n}{N}) \sum_{k=0}^{N-1} u_{k-(i+l/M)} \exp(-j2\pi \frac{(k-(i+l/M))n}{N}) = F(h_i)F(u_k)$$

[0052] However, F (-) expresses the signal after DFT of -. That is, a signal with the same frequency spectrum is acquired from all poliphase filters. Therefore, if IDFT (Inverse DFT) of this output is carried out, there will also be no misgiving and the same time series will be acquired.
[0053] Subsequently, in order to carry out matrix representation of the transfer function of the filter bank of a poliphase expression, delay matrix F (l) which a degree type defines is introduced.

[0054]
[Equation 13] phi(l) **diag [z-l z-l-1/M -- z-l-(M-1)/M]
l=-L, --, L-1 [0055] Here, ** means what "is defined" and diag (-) means the diagonal matrix which uses the vector in a parenthesis as a diagonal element. By using this delay matrix, the transfer function of a filter bank can carry out vectorial representation like a degree type.
[0056]
[Equation 14]
phi -- ** -- [-- T -- zero -- (-- z --) -- -- T -- one -- (-- z --) -- -- -- TM - one -- (-- z --) --] -- T -- = -- [-- phi (-L) -- -- phi (-L+1) -- -- -- phi (L-1) --] -- H -- [-- 0057 --] However, H=[h-L and h-L+1/M, --, hL+(M-1)/M] T expresses the impulse response of the filter before being poliphase-ized. On the other hand, in the beam formation machine expressed with several 1, when applying the sequential perturbation from the 1st antenna element 1-1, the output signal can carry out a formula expression as follows.
[0058]
[Equation 15]

$$S_k = diag[s_k \quad s_{k+1/M} \quad \cdots \quad s_{k+(M-1)/M}]^T = [W_{k,1} \quad W_{k,2} \quad \cdots \quad W_{k,N}] \begin{bmatrix} U_{k,1} \\ U_{k,2} \\ \vdots \\ U_{k,N} \end{bmatrix}$$

[0059] Uk, i and Wk in 15 above, and i are the weighting-factor matrices over the i-th output signal and output signal of antenna element 1-i, respectively, and are expressed like a degree type.
[0060]
[Equation 16] Wk, j=diag [exp(-jtheta (vk, i)) exp(-jtheta (vk+1/M, i)) -- exp (-jtheta (vk+ (M-1) / M, i))]
[Equation 17] Uk, i=diag (uk and i uk-1/M, i -- uk- (M-1) / [M, i])
[0061] If the output signal of this beam formation machine is inputted into the time-sharing filter bank circuit 10 which is the poliphase filter bank expressed with 14 above, the input signal to the adjustable amplifier 22-0 thru/or 22- (M-1) will be acquired. That is, when the inverse z transform of the output signal is inputted and carried out to 14 above, the output-signal vector psik is expressed like a degree type using the matrix defined by 15 above.
[0062]
[Equation 18]

$$\Psi_k = \begin{bmatrix} W_{k,1} \\ W_{k,2} \\ \vdots \\ W_{k,N} \end{bmatrix}^T \begin{bmatrix} U_{k+L,1} & U_{k+L-1,1} & \cdots & U_{k-(L-1),1} \\ U_{k+L,2} & U_{k+L-1,2} & \cdots & U_{k-(L-1),2} \\ \vdots & \vdots & \ddots & \vdots \\ U_{k+L,N} & U_{k+L-1,N} & \cdots & U_{k-(L-1),N} \end{bmatrix} H$$

[0063] Here, it is [Equation 19] about vector thetak and i. It introduces with thetak and i**(Uk+L, i, --, [Uk, - (L-1), i]) H. if there is no effect of a noise and conditions with ten above are satisfied here -- above -- Vector theta -- there where all the elements of k and i become the same (it is as having mentioned above using several 11 and several 12.) -- the value -- theta -- if it sets with k and i -- vector P= [1, --, 1] -- using -- Vector theta -- k and i -- [Equation 20] It is expressed thetak and i**theta k and iP. Then, 18 above is rewritten like a degree type.
[0064]
[Equation 21]

$$\Psi_k$$
$$= \sum_{i=1}^{N} \theta_{k,i} W_{k,j} P = [\cdots \quad \psi_{k,l} \quad \cdots]$$
$$= [\cdots \quad \sum_{i=1}^{N} \theta_{k,j} \exp(-j\theta(v_{k+l/M,i})) \quad \cdots]^T$$
$$l = 0, \cdots M-1$$

[0065] 21 above is a weighting factor [several 22], after once changing the signal from each antenna element 1-1 thru/or 1-N into a baseband band and passing the digital filter of transfer function T (z). WkT=[exp (j-2 theta (vk, i), --, exp (-j2theta (vk+l/M, i)), --])
The signal equivalent to what came out of and carried out weighting means being outputted from the filter of eye l/M watch of the time-sharing filter bank circuit 10 which is a poliphase filter bank. Then, weighting factors Wk and i are operated like a degree type. However, it considers as M>=N +1 (with drawing 1 thru/or the operation gestalt of drawing 3 , it is considering as M=N +1.).
[0066]
[Equation 23] Here, it is i= 1, --, N and l= 0, --, M-1 at the time of vk+l/M, i=vk, and i+delta v;i!=l at the time of vk+l/M, i=vk, and i;i!=l.
[0067] That is, in M continuous input signal sequences, a perturbation is not given to the first sample signal at all, but the perturbation is applied to the control voltage of the variable phase-shifter 3-1 connected to each component from the following sample thru/or 3-N one by one. Specifically by the l-th sample signal, a perturbation is given only to the l-th control voltage of variable-phase-shifter 3-l. The 0th filter of the time-sharing filter bank circuit 10 which is a poliphase filter bank by this (in the time-sharing filter bank circuit 10 of drawing 2) Signal psik of a non-precessing term and 0 are outputted from a digital filter 13-0 and the down sampler 14-0, and it is the l-th filter (in the time-sharing filter bank circuit 10 of drawing 2). From digital filter 13-l and down sampler 14-l, signal psik of a perturbation term to l-th antenna element 1-l and l are outputted. Therefore, it turns out that the problem mentioned above is solvable by applying a poliphase filter. That is, the adaptive array adapting a poliphase filter of the M-CMA method can ask for the optimal multiplier based on the following successive renewal types of a multiplier.
[0068]
[Equation 24] yk, i=gkpsik, and i -- here -- i= -- 0, 1, --, M-1 -- [Equation 25] ek=sigma p-|yk and 0|p -- [Equation 26] vk, i=vk -1, i+mu|ek|q-2 ek|yk, 0|p-1 (|yk, i|-|yk, 0|)
here -- i= 0, --, M-1 -- [Equation 27]
gk-1=gk-1+ mu|ek|q-2 ek|yk, 0|p-1|psik, 0| [0069] Generally, although an anti-aliasing filter is applied as a poliphase filter, since it has the analog low pass filter in front of A/D converter 9 in communication system, the anti-aliasing filter is unnecessary. So, the time-sharing filter bank circuit 10 consists of these operation gestalten by, for example, poliphase-izing the root roll-off

filter of a receiver in the nyquist filter system often used by the phase modulation system.
[0070] In drawing 1 , it is inputted into the time-sharing filter bank circuit 10 which is a poliphase filter, after passing through the low pass filter 8 which is an area JINGU filter before the A/D conversion by A/D converter 9. It is necessary to operate the digital filter 13-0 thru/or 13- (M-1) which is each root roll-off filter in the poliphase filter bank which is the time-sharing filter bank circuit 10 of drawing 2 more than by the twice of a Nyquist rate so that area JINGU distortion may not be given to a signal. Therefore, to form a root roll OFUTO filter into M-phase, it is necessary to carry out the sample of A/D converter 9 more than by 2M time of a Nyquist rate (with this operation gestalt, the sampling rate is set to f=2Mfc as mentioned above.). And after carrying out time sharing by the delay circuit 11-1 thru/or 11- (M-1) by which cascade connection was carried out, Decimation is carried out to M/2 by the M/2 twice as many down sampler 12-0 as this thru/or 12- (M-1). After passing through a digital filter 13-0 thru/or 13- (M-1), the recovery signal of the M sequence which is parallel and consists of M sample signals by which time-sharing processing was carried out is acquired by increasing decimation 4 times by the 4 times as many down sampler 14-0 as this thru/or 14- (M-1). In addition, preferably, the multiple of the down sampler 12-0 thru/or 12- (M-1) and the multiple of the down sampler 14-0 thru/or 14- (M-1) are chosen so that those products may be set to 2M.
[0071] In drawing 3 which shows the example of the time-sharing filter bank circuit 10 of operation, the exaggerated sample of the inside of 1 symbol is carried out by twice (N+1), i.e., the twice of the element number N+1 of an antenna, and it distributes to N+1 filter bank. Each filter bank calculates by the twice of a symbol rate. A perturbation is given to the variable phase-shifter 3-1 thru/or 3-N synchronously connected to each antenna element 1-1 thru/or 1-N one by one within 1 / 2 symbols on the other hand. However, a perturbation is surely reset every 1/2 symbol, namely, the signal of a non-precessing term is generated. In addition, although all perturbations were performed within 1 symbol in drawing 3 , it is also possible to give the perturbation to the variable phase-shifter of one antenna element, whenever it receives the signal of one symbol, to perform one of this at a time, and to reduce operation speed by things. In this case, the perturbation of all components is ended only after receiving the symbol signal of N individual. However, if it takes into consideration that it is necessary to insert in 1/2 symbol the period which does not give a perturbation, a sampling rate can be reduced up to 4 times of a symbol rate.
[0072] As explained above, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit 10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.
[0073] <1st modification> drawing 4 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 in the control device of the array antenna of the 1st modification concerning this invention which is the modification of the 1st operation gestalt, and beam control circuit 20a, and the same thing as drawing 1 and drawing 2 attaches the same sign.
[0074] In the 1st operation gestalt, although it had M adjustable amplifiers 22-0 thru/or 22- (M-1) between the time-sharing filter bank circuit 10 and the beam control section 21, it is characterized by having replaced with this and inserting one adjustable amplifier 22 which has the control gain gk specified by the beam control section 21 between A/D converter 9 and the time-sharing filter bank circuit 10. Although the beam control section 21 needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 2 , 0) in the beam control processing by the M-CMA method here, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 4 , and 0 on the control gain gk. Moreover, for this, instead, as a dashed line shows drawing 4 , time-sharing separation may be carried out and the baseband signaling yk before gain control and 0 (baseband signaling psik of drawing 2 , 0) may be taken out from the baseband signaling uk from

A/D converter 9.
[0075] According to the 1st modification constituted as mentioned above, in addition to the operation effectiveness in the 1st operation gestalt, the number of the adjustable amplifier 22 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.
[0076] <Operation gestalt of ** 2nd> drawing 5 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20t of beam control circuits in the control device of the array antenna which is the 2nd operation gestalt concerning this invention, is the block diagram showing the TRF circuit 61-1 of drawing 5 thru/or the detailed internal configuration of 61- (M-1) (it names generically and a sign 61 is attached hereafter.), and attaches the same sign about the same thing as drawing 1 thru/or drawing 4 , and drawing 10 . The control unit of the array antenna of this 2nd operation gestalt The transversal filter circuit which replaces with drawing 1 concerning the 1st operation gestalt, and the beam control circuit 20 of drawing 2 , and has the TDL (Tapped Delay Line; delay line with tap) circuit 70 (it is hereafter called a TRF circuit.) While having 61, it is characterized by having 21t of beam control circuits equipped with 21t of beam control sections which perform beam control of an ecad using the signal-processing M-CMA method between space-time which carries out the detail after-mentioned. Other configurations are the same as that of the 1st operation gestalt, and omit detail explanation here.

[0077] In drawing 5 , baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9 and m (m= 0, 1 and 2, --, M-1) While being inputted into the adjustable amplifier 72-0 in 21t of beam control sections, and the TRF circuit 61, the delay circuit 71-1 of two or more (L-1) individuals thru/or 71- (L-1) are inputted into the delay circuit 71-1 of the 1st step of the TDL circuit 70 which comes to carry out cascade connection. Above-mentioned baseband signaling psik and m are outputted to 21t of beam control sections, and an adder 73 through the delay circuit 71-1 of two or more (L-1) stages thru/or 71- (L-1), and adjustable amplifier 72- (L-1) while they are outputted to an adder 73 through the adjustable amplifier 72-0. In the TDL circuit 70, each delay circuit 71-1 thru/or 71- (L-1) delay for it and output only the predetermined time delay tau for the signal inputted, respectively. Here, although a time delay tau is preferably set as one half of 1 symbol time amount, it may be set, for example as less than [1 symbol time amount or it].
[0078] Delay signal bpk-1 of baseband signaling psik outputted from a delay circuit 71-1 and m=bpk is outputted to an adder 73 through the adjustable amplifier 72-1 while it is outputted to 21t of beam control sections. Moreover, delay signal bpk-2 of the baseband signaling bpk outputted from a delay circuit 71-2 are outputted to an adder 73 through the adjustable amplifier 72-2 while they are outputted to 21t of beam control sections. Furthermore, delay signal bpk-3 of the baseband signaling bpk outputted from a delay circuit 71-3 are outputted to an adder 73 through the adjustable amplifier 72-3 while they are outputted to 21t of beam control sections. Still more nearly similarly, delay signal bpk-L of the baseband signaling bpk outputted from delay circuit 71- (L-2) is outputted to an adder 73 through adjustable amplifier 72- (L-2) while it is outputted to 21t of beam control sections. The adjustable amplifier (or gain control machine) 72-0 thru/or 72- (L-1) amplify and (or gain control) output the signal inputted by the amplification degree w0 set up by 21t of beam control sections thru/or wL-1, respectively, and amplification degree (or gain) takes the value of ****** here. And an adder 73 adds delay signal bpk-1 thru/or bpk-L +1 of the baseband signaling bpk inputted and its two or more (L-1) individuals, and outputs the signal of an addition result to 21t of beam control sections as output signals yk and m (m= 0, 2 [1 and 2], --, M-1). In addition, an output signal yk and 0 are outputted also to a subtractor 24. Thus, by constituting, the TRF circuit 61 equipped with the TDL circuit 70, the adjustable amplifier 72-0 thru/or 72- (L-1), and an adder 73 is constituted. That is, each adjustable amplifier 22-0 thru/or 22- (M-1) in the 1st operation gestalt consists of the 2nd operation gestalt in the TRF circuit 61 of drawing 6 .
[0079] On the other hand, the reference signal generator 23 generates the reference signal sigma which has predetermined constant value, and outputs it to a subtractor 24. A subtractor 24 subtracts an output signal yk and 0 from a reference signal sigma, and outputs the error (or

deflection) signal ek to 21t of beam control sections. The error signal ek into which 21t of beam control sections is inputted, and baseband signaling bkk, It is based on the delay signal bkk-1 thru/or yk-L +1, and the TRF circuit 61-0 thru/or the baseband signaling yk and m (m= 0, 2 [1 and 2], --, M-1) after passage of 61- (M-1). Only a predetermined shift amount is made to precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i (i= 1, 2, --, N) of 3-N by controlling the perturbation addition circuit 30 using the signal-processing M-CMA method between space-time. Make only a predetermined response shift amount precess each amount of phase shifts which corresponds by this, and the dip vector of the power of the error signal ek outputted from the subtractor 24 to each amount of phase shifts is calculated. So that the error signal ek concerned may serve as min based on the error signal ek outputted from a subtractor 24 based on the dip vector of the power of the calculated error signal ek Each phase shift control voltage vk and i corresponding to each amount of phase shifts for turning the main beam of an array antenna 100 in the predetermined direction and each adjustable amplifier 72-0 the amplification degree w0 of 72- (L-1) thru/or wL-1 are calculated. It is outputted and set as each variable phase-shifter 3-1 thru/or 3-N and each adjustable amplifier 72-0 thru/or 72- (L-1), respectively.

[0080] In the control device of the array antenna concerning the 2nd operation gestalt constituted as mentioned above, adaptation beam control of the 20t of the beam control circuits can be accurately carried out so that an error signal ek may serve as min, the main beam of an array antenna 100 may be turned in the direction of the wave of choice and null may be turned in the direction of an interference wave. Moreover, in-phase synthesis of the delay wave of the wave of choice produced in a multi-pass transmission line can be incorporated and carried out using the TRF circuit 61, and the signal-to-noise power ratio (S/N) in the wave of choice can be improved. Moreover, although a low noise amplifier 2-1 thru/or 2-N and a variable phase-shifter 3-1 thru/or 3-N need N individual corresponding to the element number N of an antenna element 1-1 thru/or 1-N with the 2nd operation gestalt, the number of each circuitry elements is one sufficient in the circuit after the synthetic vessel 4. Therefore, as compared with the conventional example shown in drawing 10 , as compared with the conventional example, a hardware configuration is easy, and since there are few circuitry elements, there is little power consumption.

[0081] Subsequently, adaptation beam processing in which it uses with the 2nd operation gestalt is explained below. In the configuration of the adaptive array antenna concerning the 2nd operation gestalt, baseband signaling yk=yk (vk, 1, --, vk, N) can be expressed like above several 1 using a well-known equivalence low-pass model. This baseband signaling yk is inputted into the TRF circuit 61 which has the TDL circuit 70. In the TRF circuit 61, after weighting of the signal outputted from each tap of the TDL circuit 70 is carried out by the adjustable amplifier 72-0 thru/or 72- (L-1) with the amplification degree wk (i) which is a tap multiplier, respectively, it is added with an adder 73 and outputs the output signals yk and m (= it sets with zk.) shown below.

[0082]
[Equation 28]

$$z_k(v_{k,1},\ldots v_{k,N}) = \sum_{i=0}^{L-1} w_k^*(i)\ bp_{k-i}(v_{k,1},\cdots,\ v_{k,N})$$

[0083] Here, in order to perform blind control of a beam and null, minimization of the amplitude deflection of the output signal zk of the TRF circuit 61 is attained like the well-known CMA method. That is, it is [Equation 29] when the error of an output signal yk, and a 0=zk and a reference signal sigma is defined like a degree type. It becomes a requirement to satisfy the formula below ek=sigma p-|zk(vk, 1, --, vk, N) |p. However, sigma is the level of a reference signal and shows desired amplitude level.

[0084]
[Equation 30]

$$E\left[\frac{\partial e^{q}}{\partial v_{k,i}}\right]=0 \qquad (i=1,\cdots,\ N)$$

[Equation 31]

$$E\left[\frac{\partial e^{q}}{\partial v^{*}_{k,i}}\right]=0 \qquad (i=0,\cdots,\ L-1)$$

[0085] Here, p and q show the dimension of presumption of the CMA method, and in practice, the time of p=q=2 is called the CMA method and they are called Goddard's algorithm except it. By the CMA method, it cannot ask for several 30 partial differential by one above and several 28. Then, in this operation gestalt, make a variable phase-shifter 3-1 thru/or the control voltage vk of 3-N, 1, --, vk and N precess, each amount of phase shifts is made by this to precess like M-CMA concerning the 1st operation gestalt, and it asks. Moreover, it can ask for 31 above like the usual CMA method. Here, a multiplier update process is performed for an output signal zk as follows as zk=zk (vk (1), --, vk (N)).
[0086] The algorithm which looks for the solution with which 29 above is made into an error function and it is satisfied of 30 above and several 31 can be expressed like a degree type, if the principle of the well-known steepest descent method is applied.
[0087]
[Equation 32]

$$v_{k}=v_{k-1}-\mu\frac{\partial e_{k}^{q}}{\partial v_{k,i}}\fallingdotseq v_{k-1}+\mu\ e_{k}^{q-1}|\ z_{k}|^{p-2}\frac{\partial\ |\ z_{k}|}{\partial v_{k,i}}$$

[Equation 33]

$$w_{k}=w_{k-1}-\mu\frac{\partial e_{k}^{q}}{\partial w_{k}(i)}=w_{k-1}+\mu\ e_{k}^{q-1}|\ z_{k}|^{p-2}\frac{\partial\ |\ z_{k}|}{\partial w_{k}^{*}(i)}$$

[0088] 32 above and several 33 are the formulas of the algorithm for satisfying 30 above and several 31, respectively. The partial-differential term in 32 above can be acquired using the approximation of a partial differential with 26 above. On the other hand, the partial-differential term in 31 above can be directly searched for by carrying out the partial differential of the both sides with 28 above. Therefore, 32 above and several 33 become a degree type, and perform convergence processing using the renewal type of a multiplier of a degree type.
[0089]
[Equation 34] vk, i=vk -1, i+mu vekq-1|zk|p-2deltai|zk| (i= 1, --N),
[Equation 35] wk(i) =wk-1(i)+muwekq-1|zk|p-2 zk*yk (i= 0, --L-1),
[0090] However, [Equation 36] It is deltai|zk|=deltai|zk(vk, 1, --, vk and i, --, vk, N) |=|zk(vk1, --, vk, i+deltav, --, vk, N) |-|zk(vk, 1, --, vk and i, --, vk, N) |.
[0091] In 46 above, deltav is a very small term for a perturbation, and 34 above, and muv and muw in several 35 are the step sizes of the tap multiplier which are the control voltage of a phase shifter 3-1 thru/or 3-N, and the amplification degree of the adjustable amplifier 72-0 thru/or 72- (L-1), respectively. In order to carry out right convergence of the algorithm of the signal-processing M-CMA method between space-time concerning this operation gestalt, two kinds of this step size needs to satisfy the following conditions.
[0092]
[Equation 37] muw=muvdeltav -- here, the unit of deltav is a radian.
[0093] As explained above, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit 10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being

easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.
[0094] <2nd modification> drawing 7 is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 2nd modification concerning this invention which is the modification of the 2nd operation gestalt, and the configuration of beam control circuit 20ta, and the same thing as drawing 5 and drawing 6 attaches the same sign.
[0095] In the 2nd operation gestalt, although it had M TRF circuits 61-0 thru/or 61- (M-1) between the time-sharing filter bank circuit 10 and 21t of beam control sections, it is characterized by having replaced with this and inserting one TRF circuit 61 which has the weighting factor specified by 21t of beam control sections between A/D converter 9 and the time-sharing filter bank circuit 10. Although 21t of beam control sections needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 5 , 0) here in the beam control processing by the signal-processing M-CMA method between space-time, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 7 , and 0 by the weighting multiplier. Moreover, for this, instead, as a dashed line shows drawing 7 , time-sharing separation may be carried out and the baseband signaling yk before gain control and 0 (baseband signaling psik of drawing 7 , 0) may be taken out from the baseband signaling uk from A/D converter 9.
[0096] According to the 2nd modification constituted as mentioned above, in addition to the operation effectiveness in the 2nd operation gestalt, the number of the TRF circuit 61 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.
[0097] <Operation gestalt of ** 3rd> drawing 8 is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20m of beam control circuits in the control device of the array antenna which is the 3rd operation gestalt concerning this invention, and attaches the same sign about the same thing as drawing 1 thru/or drawing 7 , and drawing 10 . The control device of the array antenna of this operation gestalt is characterized by having 20m of beam control circuits which have 21m of beam control sections.
[0098] 20m of beam control circuits is based on baseband signaling psik which is an output signal from A/D converter 9, and m (m= 0, 1 and 2, --, M-1) through a demodulator 7 and the time-sharing filter bank circuit 10. The minimum an average of 2 multiplication which carries out the detail after-mentioned and which deformed (it is hereafter called the M-LMS method.) Use and only a predetermined shift amount is made to precess each amount of phase shifts of a variable phase-shifter 3-1 thru/or 3-N by controlling the perturbation addition circuit 30, respectively. The variation delta yk and m which calculated the variation delta yk and m before and behind the perturbation of the baseband signaling yk and m outputted from the adjustable amplifier 82-0 thru/or 82- (M-1) to each amount of phase shifts, and was calculated, Baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and 0, The baseband signaling yk and m outputted from the adjustable amplifier 82, baseband signaling psik and the baseband signaling yk by which gain control was carried out with the adjustable amplifier 82 in 0, 0 and the sign distinction value dk (it is the output of the sign distinction machine 83.) of that Based on the error signal ek of a between, so that the root mean square of the error signal ek concerned may serve as min It is characterized by calculating each above-mentioned amount of phase shifts and the above-mentioned gain gk for turning the main beam of the above-mentioned array antenna in the predetermined direction, and outputting to each variable phase-shifter 3-1 thru/or 3-N and the adjustable amplifier 82-0 thru/or 82- (M-1), respectively.
[0099] 20m of beam control circuits is equipped with 21m of beam control sections, the adjustable amplifier 82-0 thru/or 82- (M-1), the sign distinction machine 83, and a subtractor 84, and they are constituted. baseband signaling psi into which each adjustable amplifier 82-0 thru/or 82- (M-1) are inputted here -- the baseband signaling yk and m by which amplified k and m on the control gain gk shown by the beam control section 81, and gain control was carried out -- 21m of beam control sections -- outputting -- moreover -- among those, baseband signaling yk and 0 are outputted to the sign distinction machine 83, a subtractor 84, and 21m of beam control sections. Subsequently, the sign distinction machine 83 calculates the sign distinction

value dk of the baseband signaling yk inputted, and outputs it to a subtractor 84 so that it may mention later. Furthermore, a subtractor 84 subtracts baseband signaling yk and 0 from the sign distinction value dk, and outputs the error signal ek of a subtraction result to the beam control section 81. And the beam control section 81 calculates the adjustable control voltage vk and i (i= 1, 2, —, N), and outputs it to a variable phase-shifter 3-1 thru/or 3-N, respectively while it calculates the control gain gk using the M-LMS method based on an error signal ek in baseband signaling psik inputted, 0 and yk and m, and a list and outputs it to the adjustable amplifier 82.
[0100] In the predetermined training period before performing data transmission in this beam control circuit 80 only based on baseband signaling psik after A/D conversion, using the M-LMS method By making only a predetermined shift amount precess each variable phase-shifter 3-1 thru/or each phase shift control voltage vk and i to 3-N by controlling the perturbation addition circuit 30 The variation delta yk and m which calculated the variation delta yk and m before and behind the perturbation of the baseband signaling yk and m outputted from the adjustable amplifier 82 to each amount of phase shifts, and was calculated, Baseband signaling psik outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and 0, The baseband signaling yk and m outputted from the adjustable amplifier 82-0 thru/or 82- (M-1), baseband signaling yk, 0 sign distinction values dk (it is the output of the sign distinction machine 83.) Based on baseband signaling yk and the error signal ek between 0, so that the root mean square of the error signal ek concerned may serve as min Each above-mentioned amount of phase shifts and the above-mentioned gain for turning the main beam of the above-mentioned array antenna in the predetermined direction are calculated, and it outputs to each variable phase-shifter 3-1 thru/or 3-N and the adjustable amplifier 82-0 thru/or 82- (M-1), respectively.

[0101] In the control device of the array antenna constituted as mentioned above, 20m of beam control circuits forms the main beam of an array antenna 100 in the predetermined direction accommodative so that the root mean square of the error signal ek generated with the subtractor 84 of 20m of beam control circuits may serve as min. Although a low noise amplifier 2-1 thru/or 2-N and a variable phase-shifter 3-1 thru/or 3-N need N individual corresponding to the element number N of an antenna element 1-1 thru/or 1-N in the control unit of the constituted array antenna, the number of each circuitry elements is one sufficient in the circuit after the synthetic vessel 4. Therefore, as compared with the conventional example shown in drawing 10 , a hardware configuration is easy, and since there are few circuitry elements, there is little power consumption.
[0102] Subsequently, the control algorithm in 20m of beam control circuits is explained. First, the baseband signaling yk and m which is outputted from the adjustable amplifier 82-0 thru/or 82-(M-1) and by which gain control was carried out is expressed with a degree type.
[0103]
[Equation 38] yk, m=gkpsik, m [0104] Here, psik and m are the baseband signaling which was outputted through the time-sharing filter bank circuit 10 from A/D converter 9, and was expressed with complex, gk is the gain of the adjustable amplifier 82-0 thru/or 82- (M-1) expressed with the real number, and yk and m show each output signal of the adjustable amplifier 82-0 thru/or 82- (M-1) expressed with complex. At this time, an error signal ek is defined like a degree type.
[0105]
[Equation 39] ek=dk-yk, 0 [0106] Here, dk is an output signal which shows the sign distinction value from the sign distinction machine 83, and is calculated like a degree type.
[0107]
[Equation 40] dk=sgn[Re(yk)]+j-sgn [Im (yk)]
[0108] Here, Re [-] is a function which shows the real number of an argument, and Im [-] is a function which shows the imaginary of an argument. Moreover, sgn [x] is a sign discriminant function and is defined as follows.
[0109]
[Equation 41] sgn[x]
= At the time of 1; x>=0 = it is [0110] at the time of -1; x<0. At this time, the gain of each

adjustable amplifier 82-0 thru/or 82- (M-1) is updated like a degree type.
[0111]
[Equation 42] gk=gk-1+muRe [psik, 0ek*]
[0112] Here, mu is called a step size parameter and is the suitable constant of 0< mu<1. Moreover, * shows a complex conjugate. On the other hand, the control voltage of variable-phase machine 3-i is updated like a degree type.
[0113]
[Equation 43] vk, i=vk -1, i+mu Re (ek*delta yk and i)
[0114] At this time, Variation delta yk and i is calculated like a degree type.
[0115]
[Equation 44] deltayk, i=yk, 0 (1 vk- 1, 1, --, vk- 1, i+deltav, --, vk- N)
- yk, 0 (1 vk- 1, 1, --, vk- 1, i, --, vk- N)
[0116] phase shift control voltage vk- of the time of day k-1 in case the 2nd term of the several 44 right-hand side does not add a perturbation electrical potential difference -- 1, 1, --, vk-1, i, -- and the baseband signaling yk with which gain control of [when impressing vk-1 and N to each variable phase-shifter 3-1 thru/or 3-N] was carried out are shown. moreover, the 1st term of the several 44 right-hand side -- phase shift control voltage vk- of time of day k-1 -- 1, 1, --, vk-1, i, --, vk-1, and N -- in addition, the baseband signaling yk with which gain control of [when applying perturbation electrical-potential-difference deltav to an excess] was carried out only to variable-phase-shifter 3-i corresponding to i-th antenna element 1-i, and 0 are shown. And delta yk(s) and i which are expressed with several 44 are the variation yk of these two signals, i.e., the baseband signaling before and behind perturbation, and the variation of 0.
[0117] Therefore, based on the baseband signaling yk before and behind the calculated perturbation, the variation delta yk and i of 0, and an error signal ek, the phase shift control voltage vk and i is calculated and set up so that clearly from several 43. And the adjustable amplifier 82-0 thru/or the gain gk of 82- (M-1) are determined and set up so that from several 42, and the root mean square of an error signal ek may serve as min. Thus, by carrying out beam control, by using the pilot signal used by the preamble especially used by TDMA etc., CDMA, etc. as a request signal, the main beam of the array antenna concerned can be turned in the predetermined direction, and a subcarrier pair interference wave power ratio (CIR) turns a beam in the direction of a request wave, also when level is lower than an interference wave, and minus, i.e., a request signal, can form null in the direction of an interference wave.
[0118] In this operation gestalt, digital signal processing performs amplitude control to the output baseband signaling yk and m which minded the time-sharing filter bank circuit 10 from A/D converter 9, and by variable-phase-shifter control of a microwave band (RF band), since a phase-shifter input signal cannot be observed, the amount of updating of a multiplier is calculated by the perturbation. Moreover, by amplitude control, since the output baseband signaling yk and m is acquired as a digital signal, an amplitude presumption algorithm is obtained in several 42 format. Moreover, since the invented algorithm uses the same norm as the well-known LMS method of minimization of the mean square of an error signal ek, it is calling the invented algorithm the "M-LMS method."
[0119] the adaptive array realized in the DBF circuit since beam control was carried out using the M-LMS method according to this operation gestalt as explained above -- the same -- a beam and null -- it can control and is -- in addition, since RF band can perform beam shape **, there is an advantage that the cutback of circuit magnitude or cost is attained as compared with the conventional example. Therefore, a configuration is easy and there is little power consumption. Moreover, by using the pilot signal used by the preamble used by TDMA etc., CDMA, etc. as a request signal, a subcarrier pair interference wave power ratio (CIR) turns a beam in the direction of a request wave, also when level is lower than an interference wave, and minus, i.e., a request signal, can form null in the direction of an interference wave. Therefore, even if it is an inferior environment, adaptation actuation can be carried out to stability.
[0120] Moreover, according to this operation gestalt, the signal of two or more perturbation terms which the rate of the signal which should be processed is reduced and corresponds to each antenna element can be taken out to accuracy by using the time-sharing filter bank circuit

10 which is a poliphase filter bank. Therefore, the A/D converter which can perform a very high-speed sampling as compared with a bit rate is not needed, but since it becomes a low speed, timing adjustment of a sampling also becomes easy. so, circuitry -- being easy -- time accuracy -- and control of the main beam and control of null are made to accuracy as a beam formation direction.

[0121] <3rd modification> drawing 9 is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 3rd modification concerning this invention which is the modification of the 3rd operation gestalt, and the configuration of beam control circuit 20ma, and the same thing as drawing 8 attaches the same sign.

[0122] In the 3rd operation gestalt, although it had the adjustable amplifier 82-0 thru/or 82- (M-1) between the time-sharing filter bank circuit 10 and 21m of beam control sections, it is characterized by having replaced with this and inserting one adjustable amplifier 82 which has the weighting factor specified by 21m of beam control sections between A/D converter 9 and the time-sharing filter bank circuit 10. Although 21m of beam control sections needs the baseband signaling yk before gain control, and 0 (baseband signaling psik of drawing 8 , 0) in the beam control processing by the M-LMS method here, this is calculable by doing the division of baseband signaling psik outputted from the time-sharing filter bank circuit 10 of drawing 9 , and 0 on the control gain gk. Moreover, for this, instead, as a dashed line shows drawing 9 , time-sharing separation may be carried out and the baseband signaling yk before gain control and 0 (baseband signaling psik of drawing 9 , 0) may be taken out from the baseband signaling uk from A/D converter 9.

[0123] According to the 3rd modification constituted as mentioned above, in addition to the operation effectiveness in the 3rd operation gestalt, the number of the adjustable amplifier 82 can be decreased substantially and this has the characteristic effectiveness that circuitry can be simplified more.

[0124] In the operation gestalt more than modification > besides <, although digital signal processing is performed in the subsequent circuit after carrying out A/D conversion of the baseband signaling using A/D converter 9, A/D converter 9 may not be inserted but signal processing may be analogically performed in a subsequent circuit.

[0125] In the above operation gestalt, although the perturbation addition circuit 30 consists of circuits where each beam control circuits 20, 20a, and 20t, 20ta, 20m, and 20ma are another, it may unify and constitute the function of the perturbation addition circuit 30 from software or hardware circuitry in each beam control circuits 20, 20a, and 20t, 20ta, 20m, and 20ma.

[Translation done.]

EXAMPLE

[Example] Furthermore, since this invention persons experimented in the interference oppression property of the adaptive array adapting a poliphase filter of the M-CMA method concerning the 1st operation gestalt by computer simulation, they explain the experiment approach and experimental result in full detail below.
[0127] It was premised on the transmitter-receiver configuration which applied differentially coherent detection to the wave detector, using a QPSK modulation technique as a modulation technique. Moreover, the transmission line applied the AWGN (Additive White Gaussian Noise) channel. An antenna is a linear array antenna of half-wave length spacing, and the element number was set to 4. moreover -- if the direction of a transverse plane of a linear array antenna is made into 0 times -- the wave of choice -- the direction of -50 degrees to an interference wave -- from the direction of 30 degrees -- etc. -- the environment which carries out incidence on level was assumed. Moreover, the multiplier of the M-CMA method was set as p=q=1, and it considered as the step size mu= 0.0001. The exaggerated sample carried out by 4 times the symbol rate for reduction of processing speed. Moreover, the initial state of an array antenna forms the beam in the direction of a transverse plane.
[0128] Drawing 11 is as a result of [of the 1st operation gestalt] simulation, and is a graph which shows the directivity response pattern in the case of a four-element linear array antenna. The beam which has the about 12dB array factor of a theoretical limitation in the direction of the wave of choice is formed so that clearly from drawing 11 . It turns out that deep null can be formed in the direction of an interference wave. However, when SNR is low, the location of null is shifted a little. Control concentrates on the direction which forms a beam and this is considered for sensibility to fall to null somewhat, when SNR is low.
[0129] Drawing 12 is as a result of [of the 1st operation gestalt] simulation, and is a graph which shows the property of a bit error rate (BER) over the subcarrier/noise power ratio in the case of a four-element linear array antenna (CNR). In drawing 12 , the property of the differentially coherent detection at the time of the four-element maximum ratio composition diversity reception in conditions without interference is shown as a theoretical value. Since the adaptive array using the M-CMA method not only turns a beam to the wave of choice, but can form sharp null in the direction of an interference wave, in all CNR conditions, it turns out that the outstanding property which carries out asymptotic to a theoretical value even at 1.5dB is acquired. It is thought that this 1.5dB degradation is based on the sensibility lowering to the null mentioned above.
[0130] As explained above, the poliphase filter was used as the effective implementation approach of the M-CMA method which enables adaptation beam control in the analog beam shape molding adaptive array in which small and low-pricing are possible. In the renewal type of a multiplier of the M-CMA method, the "perturbation term" and "a non-precessing term" of this time of day are theoretically needed. It uses that consider as the approach of acquiring this signal simply, and the time-sharing filter bank circuit 10 equipped with each filter bank which constitutes a poliphase filter outputs the completely same wave as this time of day. That is, different perturbation for every filter or a non-precessing term is outputted to each poliphase filter in the time-sharing filter bank circuit 10 by distributing the signal which does not receive a

perturbation with a carrier beam signal.
[0131]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of the control device of the array antenna which is the 1st operation gestalt concerning this invention.
[Drawing 2] It is the block diagram showing the detailed internal configuration of the time-sharing filter bank circuit 10 of drawing 1 , the beam control circuit 20, and the perturbation addition circuit 30.
[Drawing 3] It is the block diagram showing the example of the time-sharing filter bank circuit 10 of drawing 2 of operation.
[Drawing 4] It is the block diagram showing the configuration of the time-sharing filter bank circuit 10 in the control device of the array antenna of the 1st modification concerning this invention which is the modification of the 1st operation gestalt, and beam control circuit 20a.
[Drawing 5] It is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20t of beam control circuits in the control device of the array antenna which is the 2nd operation gestalt concerning this invention.
[Drawing 6] It is the block diagram showing the detailed internal configuration of the TRF circuit 61 of drawing 5 .
[Drawing 7] It is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 2nd modification concerning this invention which is the modification of the 2nd operation gestalt, and the configuration of beam control circuit 20ta.
[Drawing 8] It is the block diagram showing the configuration of the time-sharing filter bank circuit 10 and 20m of beam control circuits in the control device of the array antenna which is the 3rd operation gestalt concerning this invention.
[Drawing 9] It is the block diagram showing the time-sharing filter bank circuit 10 in the control device of the array antenna of the 3rd modification concerning this invention which is the modification of the 3rd operation gestalt, and the configuration of beam control circuit 20ma.
[Drawing 10] It is the block diagram showing the configuration of the control device of the array antenna of the conventional example.
[Drawing 11] It is as a result of [of the 1st operation gestalt] simulation, and is the graph which shows the directivity response pattern in the case of a four-element linear array antenna.
[Drawing 12] It is as a result of [of the 1st operation gestalt] simulation, and is the graph which shows the property of a bit error rate (BER) over the subcarrier/noise power ratio in the case of a four-element linear array antenna (CNR).
[Description of Notations]
1-1 thru/or 1-N -- Antenna element
2-1 thru/or 2-N -- Low noise amplifier (LNA),
3-1 thru/or 3-N -- Variable phase-shifter,
4 -- Synthetic vessel,
5 -- Down converter,
6 -- Band-pass filter (BPF),
7 -- Demodulator,
8 -- Low pass filter (LPF),

9 -- A/D converter
10 -- Time-sharing filter bank circuit,
11-1 thru/or 11 -(M-1)-- Delay circuit,
12-0 thru/or 12 -(M-1)-- Down sampler,
13-0 thru/or 13 -(M-1)-- Digital filter,
14-0 thru/or 14 -(M-1)-- Down sampler,
20, 20a, 20t, 20ta, 20m, 20ma -- Beam control circuit,
21, 21t, 21m -- Beam control section,
22-0 thru/or 22 -(M-1)-- Adjustable amplifier,
23 -- Reference signal generator,
24 -- Subtractor,
30 -- Perturbation addition circuit,
31 -- Perturbation addition voltage generator,
32 -- Switch controller,
33-1 thru/or 33-N -- Adder,
34-1 thru/or 34-N -- Switch,
61, 61-0, or 61 -(M-1)-- Transversal filter circuit (TRF circuit),
70 -- TDL circuit,
71-1 thru/or 71 -(L-1)-- Delay circuit,
72-0 thru/or 72 -(L-1)-- Adjustable amplifier,
73 -- Adder,
100 -- Array antenna.

[Translation done.]